／
SCHOOL SCIENCE AND MATHEMATICS

VOL. XI. No. 3 CHICAGO, MARCH, 1911 WHOLE No. 86

AN OUTLINE OF THE MANUFACTURE OF IRON AND STEEL.[1]

BY B. D. QUARRIE,

Asst. Gen. Supt. Newburgh Steel Works and Blast Furnaces.

The iron and steel industry of our country occupies first place, in the capital invested and number of men employed. It is therefore of great importance. The uses are varied and of increasing importance, and, instead of being narrowed, the field is constantly being opened in new directions, steel replacing copper, brass, tin, and aluminum in places where it was not thought available before.

The history of the iron and steel industry from the Catalon forge to the electric furnace has been one of vast importance in the bearing it has had on the wealth of the countries fortunately situated by reason of available supplies of ore, coke, or forests and limestone.

There were produced in the United States and Canada—

In the Year	1880	1890	1900	1909
Tons iron ore	7,000,000	16,000,000	27,500,000	53,000,000
" pig iron	4,000,000	9,000,000	14,000,000	26,500,000
" steel	1,250,000	4,300,000	10,000,000	25,000,000
" coke	3,500,000	11,500,000	20,500,000	41,000,000

The increase in production of steel is not in accordance with increase in pig iron, due to fact that the remelting of steel scrap contributed to increase in steel.

The fact that for each ton of pig iron produced it is necessary to consume approximately two tons of ore, one ton coke, and one half ton of limestone, the magnitude of the industry is apparent.

It has been said that the steel business is a true barometer of general business conditions, and it has invariably been true.

[1]Read before Chemistry Section, C. A. S. and M. T., at the Cleveland meeting, Nov. 25, 1910.

It is not in the province of a short paper to dwell very extensively on details of the processes going to make up the cycle in the manufacture of steel. I will touch on the important points and draw out the chemical changes going on in the various processes, viz., (1) Blast Furnace, (2) Basic Bessemer, (3) Acid Bessemer, (4) Basic Open Hearth, (5) Acid Open Hearth.

The crucible steels, high speed tool steels, and, etc., are refinements with the six mentioned as fundamentals in the manufacture.

The Blast Furnace.

Ores used in smelting:

(1) Carbonate ($FeCO_3$), contains when pure only 48% iron and is usually roasted before using in the blast furnace.

(2) Hematite (Fe_2O_3), when pure contains 70% iron. It occurs either as specular ore, reddish brown or yellow. Best known deposits are the Lake Superior district and Alabama, which has a great deposit of lean ores.

(3) Magnetite (Fe_3O_4), contains 72.41% iron when chemically pure. The lean deposits of magnetite in New York and Pennsylvania are usually magnetically concentrated.

The process used for smelting pig iron depends upon the character of raw materials. Fuels used in smelting are charcoal, hard coal, raw coal, and coke.

Charcoal was the primitive fuel and is still used in some localities, but such iron can be left out of the question in connection with steel making pig iron, as it is little used except in Sweden and the Ural mountains, where no other fuel is available.

Hard coal is used sparingly mixed with coke. Raw coal is used in blast furnaces in Scotland, but it is low in volatile matter and no serious trouble is encountered.

Coke is universally the fuel used for smelting, and the working of a blast furnace depends upon its quality as much as upon the quality of the ores.

The Connellsville district in Pennsylvania has been a producer, for many years, of the finest quality of coke the world has seen, and it has been used universally throughout the districts in the north and eastern parts of the United States.

The West Virginia cokes are not as good, but from necessity are being used, as are also many grades of coke made in by-product ovens from coals which would be failures in beehive ovens, but by judicious mixing are being used to produce suitable fuel.

The use of by-product coke in this country is not very general, but it will not be long before it will be necessary to extend operations along that line, due to failure of the Connellsville fields. The manufacture of coke in bee-hive ovens is a wasteful operation, and we will be compelled to emulate our German friends and conserve our coal supplies.

Limestone occurs universally and can be obtained in a reasonably pure state for use in smelting. In rare cases limestone does not of necessity become a part of the charge of a blast furnace, but its use is very general. The materials charged into a blast furnace—coke, ore, and limestone—are productive of gas, slag, and pig iron.

(1) Fuel:

The effect of heated gases on fuel is very little, a small percentage is dissolved by CO_2, but it is not materially changed until it comes before the tuyeres, where it comes in contact with the blast and is rapidly consumed, forming CO_2 which is immediately reduced to CO, which, with the nitrogen of the blast, forms the upward current of gas. The residual ash continues downward and becomes part of the slag.

The change in the flux is very different; when it has reached about 1,000° F. it begins to decompose and loses some of its CO_2, which joins the upward current of gases, leaving as residues CaO, as follows:

$$CaCO_3 + \Delta = CaO + CO_2.$$

As the temperature increases the decomposition is more rapid and by time it reaches the bosh all the CO_2 has been eliminated and only CaO remains.

CaO is infusible even at the highest blast furnace temperature, but in presence of the silicious and aluminous gangue of ore and ash of coke forms a fusible silicate making up the slag.

The function of the slag is the elimination of the impurities, SiO_2, Al_2O_3, CaO, MgO and sulphur from materials going into the top of the furnace. The entire action in a blast furnace is the elimination of these materials and formation of iron by reducing action, as against an oxidizing action in the Bessemer and open hearth processes. The change which takes place in the ore occurs mostly higher up in the furnace, and is usually attacked first. Unlike the stone its change is not due to heat alone, but to the reducing action of the gases, and is therefore chemical in its nature.

Easily reduced ores are affected at 400° F., and the action becomes more rapid as temperature increases. Through the loss of its oxygen the ore is changed to finely divided sponge of metallic particles, which undergoes no change until it reaches the fusion zone, where it is melted.

The gases result from a blast of heated air blown in at tuyeres under 10 to 20 pounds pressure, same coming into contact with highly heated coke, the carbon of which unites with the air to form CO_2—

$$C + O_2 = CO_2$$

The CO_2 formed by combustion of coke immediately comes into contact with fresh incandescent coke forming CO by reaction—

$$CO_2 + C = 2CO.$$

The action of CO on oxides of iron results in deposition of carbon and removal of oxygen: thus $3CO + Fe_2O_3 = Fe_2 + 3CO_2$, and facilitating the deposition of carbon; the presence of finely divided sponge iron causes—

$$2CO = CO_2 + C,$$

and the deposition of C on the finely divided iron and in all the crevices tends to disintegrate it.

Hydrogen also acts as strong reducing agent; when passed over heated iron it deoxodizes it more readily than Co—

$$Fe_2O_3 + 3H_2 = Fe_2 + 3H_2O,$$

but from the fact that it is present in appreciable quantities in the escaping gases, would seem to indicate that it does not perform this function, but it may assist by reducing CO_2 to CO, thus $H_2 + CO_2 = H_2O + CO$, which indirectly helps reduction. The presence of hydrogen is due principally to decomposition, at tuyeres, of moisture entering with the blast, and usually amounts to from 1 to 3% of the gases by volume.

The nitrogen in the gas is practically inactive, except a tendency to form cyanogen and unite with hydrogen to form ammonia. As these are both deoxidizers, the gases, as they begin to ascend, are strongly reducing in their action.

To sum up the whole action of CO_2 and CO on the various materials: At 400° F. and upward, CO reduces oxides of iron with formation of CO_2—

$$Fe_2O_3 + 3CO = 2Fe + 3CO_2.$$

430° F. to 900° F. CO is decomposed by sponge iron and carbon deposited and CO_2 formed—

$$2CO + Fe_2 = Fe_2 + C + CO_2.$$

710° F. and upward CO_2 attacks solid carbon to form CO—

$$CO_2 + C = 2CO.$$

720° F. and upward, solid carbon reduces oxides of iron with formation of CO—

$$C + FeO = Fe + CO.$$

760° F. and upward CO_2 oxidizes metallic sponge with formation of CO—

$$CO_2 + Fe_x = Fe_xO + CO.$$

1,100° F. and upward $CaCO_3$ is decomposed with evolution of CO_2, which is at once resolved to CO—

$$CaCO_3 = CaO + CO_2$$

The smelting of the other constituents is as follows—

A portion of $SiO_2 + 2C = Si + 2CO.$

The silicon uniting with the iron—

$$2FeS + 2CaO + C = 2CaS + Fe_2 + CO_2.$$

The CaS going out in slag—

$$MnO_2 + 2C = Mn + 2CO.$$

$$P_2O_5 + 5C = 2P + 5CO.$$

From the nature of the operation the phosphorus all unites with the iron and depending upon the condition of furnace whether run basic or acid, varying percentages of the manganese remain in the iron, the rest going into the slag. The more basic and hotter the slag the more remains in iron and less goes off with the slag.

The relation of the amount of CO to CO_2 in the gases at top of furnace vary with the pounds of fuel used per ton of iron, and varies from 10 to 17 per cent CO_2 and 22 to 27 per cent CO, 2 per cent hydrogen and about 60 nitrogen. This valuable fuel is used to raise steam, heat the entering blast and purified with water, to eliminate the dust, is used to furnish the fuel for internal combustion engines, driving blowing engines and electrical accessories of the modern blast furnace plant; and sufficient gas is generated over and above the amount needed to operate furnace plant to furnish power to run other mills.

Of the total amount of pig iron made in this country, about 3% is remelted and made into malleable cast iron, about 15% is remelted and made into grey iron castings, 40% is purified in the Bessemer converters, 40% in the open hearth, and about 2% in the puddling furnaces to make wrought iron.

In case of purification of pig by either Bessemer or open hearth processes, the pig iron is usually tapped from furnaces

into ladles and transported to mixers holding from 250 to 750 tons, and maintained in molten condition. These mixers are large boiler plate containers lined with fire brick, and can be controlled hydraulically in such a way as to pour out whatever amount is needed at the consuming department.

Analyses of pig iron vary according to uses made of same. In the case of pig iron used for Acid Bessemer or Acid Open Hearth processes, the phosphorus must of necessity be low, due to fact that it is not eliminated or affected in either process. The heat resulting from the combustion of Si, Mn, and C in the above mentioned processes is what constitutes the necessary element in the reaction.

In the Basic Bessemer and open hearth processes the phosphorus furnishes the major part of heat of reaction, and must, therefore, be high in pig iron used.

TYPICAL ANALYSES OF PIG IRON FOR VARIOUS USES.

KIND	SILICON	SULPHUR	PHOS.	MN.
Foundry	1.25 to 3.00	.065 to .035	.30 to 1.00	.20 to 1.50
Bess. Acid ...	.80 to 2.00	under .080	under 1.00	.35 to .75
Bess. Basic ..	under 1.00	under .080	1.75 to 3.50	1.00 to 2.00
O. H. Acid ..	1.00 to 2.50	under .050	under .050	.35 to .75
O. H. Basic ..	under 1.00	under .050	.10 to 2.00	.75 to 3.00
Ferromanganese	.50 to 1.00	under .03	.10 to 1.00	80
Spiegel	under 1.00	under .05	under .150	15 to 25

The Bessemer Converter:

The Bessemer Converter consists of a steel shell riveted together, pear shaped and supported by two trunnions, one of which is hollow, the other connected to a pinion which engages a rack, joined to a hydraulic piston, which is long enough to permit of the rotating of converter through at least 270° and more often all way round or 360°. The shape of converter is such that when it is lying on its side, the metal will not cover any of the tuyere holes which are put in bottom to serve as passage for wind from blowing engine through hollow trunnion into wind box, thence through tuyeres into converter. This shape is necessary in order to be able to turn off blast without having molten metal run down into wind box.

The lining is highly refractory and of such a nature as to be as nearly neutral as possible to the slag formed from the reactions; in the case of acid Bessemer it is of acid material, sand stone, or gannister rock and mica shist laid up with small amount of refractory clay. In the acid process the bottoms are

made by placing tuyere blocks in position, then ramming clay and gannister round them.

Action of Converter:

After vessel is thoroughly heated it is turned on its side, proper amount of iron poured in, and the wind is turned on and vessel elevated to vertical position. The blast now blows through the 20 inches or so of metal in a wide spray of tiny bubbles of air until the impurities are oxidized, when it is again turned into horizontal position and wind cut off. Anticipating this a predetermined amount of spiegel or ferromanganese is made ready to throw into the ladle at same time the metal is being poured from the converter.

The action which takes place between the recarburizer and the impurities in the bath are as follows:

$$(1)\ Mn + FeO = MnO + Fe.$$
$$(2)\ C + FeO = CO + Fe.$$

Reaction No. 2 produces a boil in the bath in ladle, which serves to distribute the elements uniformly.

Reaction No. 1 removes a large amount of oxygen from the metal and takes some of the manganese in the recarburizer into the slag; a slight loss in Si from the recarburizer takes place from the following reaction:

$$(3)\ Si + 2FeO = SiO_2 + 2Fe.$$

All these losses are discounted in calculating the resultant steel. After reaction is completed the steel is poured from the ladle into ingot molds by means of suitably arranged stopper and nozzle in bottom of ladle.

The blower who stands in a "pulpit" is in charge of the operation of converter and pouring the steel from converter into ladle. He is able, after some experience, to catch heats at the right time to "turn down" and an "off" heat is rare occurrence with reliable blowers. He has scrap to control, the temperature of heats and also steam which is admitted with the blast. The decomposition of steam quickly reduces the temperature of the blow.

The Chemistry of the Process:

If a stream of air is made to impinge on a melted bath of iron the metal and impurities will be immediately oxidized about in proportion to the relative amounts of each present. The chemistry of the Bessemer process, therefore, consists of the union of oxygen from tuyeres with the first element with which

it comes in contact and a subsequent attack on these oxidized elements by unoxidized ones for their oxygen. As iron is the predominant element, and as the oxides of iron are readily reduced, they serve as carriers of oxygen between air and other impurities.

$$(a)\ FeO + Mn = Fe + MnO.$$
$$(b)\ FeO + C = Fe + CO.$$
$$(c)\ 2FeO + Si = 2Fe + SiO_2.$$

In the early part of blow the carbon oxides suffer reduction.

$$(d)\ 2CO + Si = SiO_2 + 2C.$$
$$(e)\ CO_2 + Si = SiO_2 + C.$$
$$(f)\ CO + Mn = MnO + C.$$

Chemical equilibrium is established by the elements. Some iron oxide survives, however, and being predominant it unites with SiO_2 to form a silicate—

$$(g)\ FeO + SiO_2 = FeSiO_3.$$

This ferrous silicate with manganese silicate forms a slag which dissolves oxides of iron. Even after these oxides of iron are absorbed in the slag they may be reduced again by Mn and C by reactions (*a*) and (*b*).

$$(h)\ MnO + SiO_2 = MnSiO_3.$$

The slag formed is result of the silicates of manganese and iron dissolving in each other; this slag will dissolve large amounts of iron oxide, manganese oxide, silica and some alumina from the lining, and the slag itself serves as a carrier of oxygen to the impurities.

As the temperature of the blow rises on account chiefly of oxidation of silicon, the affinity of carbon for oxygen increases more than that of the other impurities and reaction (*d*) reverses:

$$(i)\ SiO_2 + 2C = 2CO + Si.$$

This critical temperature is somewhere between 2,600° and 2,850° Fahr., and unless silicon is all oxidized before this temperature is reached there will be silicon in appreciable amounts left in the steel.

There is also a critical temperature for manganese oxidation above which, reaction (*f*) is liable to be reversed and manganese left in the steel, but this happens only when the pig iron contains high manganese.

No warning is given of the approach of these critical temperatures because there is nothing but a shower of sparks emanating from the mouth of the vessel until the carbon begins to

burn, and operator can form little idea of the degree of heat until too late.

The second period in the blow begins when the carbon begins to burn, which, in America, is after the practical elimination of the silicon and manganese. In this period the only reaction is the burning of carbon. The phosphorus and sulphur remain about the same because the acid slag will not absorb either.

Recarburizing: The operation of recarburizing is adding requisite amount of carbon to the bath of metal to bring to desired amount. Ferromanganese contains 6 to 7% of carbon, and for making of various grades of steel varying amounts are used.

Basic Bessemer Practice.

The Basic vessel is same as acid except that it is lined with calcined dolomite rammed into place with tar.

The object of this basic lining is to resist chemical action of the slag. Before beginning the blow about 15% in weight of lime is added to bath in the vessel, in order to form a basic slag, take up silica formed, and protect the lining.

The basic blow is similar to the acid except that at point where carbon is eliminated the phosphorus has not yet been attacked, as its chemical affinity for oxygen is less than that of carbon. The blow is therefore continued for a few minutes, during which the phosphorus is oxidized and absorbed by the basic slag as phosphate of lime. The use of flame for afterblow proves unsatisfactory and it is usually handled by a time element.

In recarburizing a basic heat the presence of slag is liable to cause a reduction of the phosphorus from the slag and it will again enter the bath so that it is necessary to pour clean metal. The amount of basic slag will be about 25% of weight of iron charged and will contain about 9% of iron.

The basic is more expensive to operate than acid. Longer time for blows, greater lining costs, and fewer heats per lining. The basic process is not used in America to any extent, but is used a good deal in Germany to handle the high phosphorus ores of the Minette district.

The Basic Open Hearth Process.

The function of the basic lining is to remain inert and serve simply as a container for the bath. The construction of basic and acid open hearth furnace differs only in the character of the bottom; in the former calcined dolomite and magnesite are used, and in the latter silica sand.

The charge in a basic open hearth consists of pig iron, scrap of all kinds, roll scale or ore and limestone.

In order that the slag shall be at all times rich in lime the stone is added with charge, and later during the melting—in case the melter sees it is necessary, due to a too fluid slag—the higher the silicon and phosphorus in the charge the greater the lime necessary. Ore or scale has very little effect on a basic lining, but will rapidly affect a silicious lining.

It takes two or three hours for the charge to melt and during that time the silicon has been materially reduced while the carbon, manganese, and phosphorus are also reduced.

The changes which take place are in control of the melter, as it is necessary for the success of the operation to eliminate the carbon last, so that it is necessary at times to add pig iron to melted charge in order to bring up the carbon. On the other hand if phosphorus is being eliminated very fast the oxidation of carbon may be hastened by adding ore to the charge.

If the phosphorus is eliminated after the carbon a great deal of iron will be oxidized because the phosphorus does not protect the iron as well as free carbon. In ordinary open hearth plants the melter takes out a small test ladle full of metal at intervals, and, after cooling and breaking he is able to judge the carbon contents very closely, and near the end of the reaction his judgment is verified by laboratory tests.

It is sometimes the practice to catch the higher carbon heats coming down, i. e., to eliminate the carbon only to desired percentage and then tap the heat. In others for all grades of steel it is the practice to eliminate all the carbon, then use recarburizer to bring the metal to desired percentage.

The functions of the slag are to absorb and retain the impurities in the metal, particularly silicon, phosphorus, and manganese, and as much sulphur as possible, to form a blanket over the bath to protect it from oxidizing excessively from flame, and to oxidize impurities in the bath by acting as a carrier of oxygen from furnace gases to impurities in the metal.

For the retention of phosphorus and sulphur the slag must be rich in bases. For the oxidizing it is necessary that the slag be fluid in order to mix easily with the bath and therefore lime content must not be too high.

During the boil when the carbon is passing off there is an intimate mixture of metal and slag, and it is so violent at times that large surfaces of metal are exposed to the oxidizing influence of the gases.

Removal of sulphur is a variable quantity, but there is usually a large loss of that element during the operation in spite of additions of sulphur from the coal used to make the gas.

The removal of sulphur is greatly enhanced if the slag is thinned out by addition of fluor spar just before the end of the operation. It is of great importance that the final slag shall be a nonoxidizing one, else the metal itself will be full of oxides and "wild" on casting.

Recarburizing:

In basic open hearth practice it is necessary to add recarburizer to stream of metal as it runs into ladle. If it were added in presence of a basic slag the following would take place—

$$2(3CaO—P_2O_5) + 5C = 6CaO—P_2O_5 + 5CO + P_2$$

$$4(3CaO—P_2O_5) + 5Si = 2(6CaO—P_2O_5) + 5SiO_2 + 4P$$

and the phosphorus reënter the metal.

The recarburizer used is either ferromanganese, coal, charcoal, or coke.

Acid Open Hearth.

Acid open hearth practice is similar to basic, but operations are simpler because phosphorus and sulphur are not eliminated; it is therefore necessary to start with pig iron and scrap low in these elements. The manganese is not usually as high in pig iron for acid work as in basic. The manganese and silicon are usually reduced to a trace by time charge is all melted and slag formed in acid furnace is all or nearly all a combination of $(FeO + MnO)$ silicates.

The above outlined methods are used singly or in various combinations.

The Talbot furnace contains a charge as high as 200 tons in some cases. The metal bath is three feet deep as against 15 to 20 inches in ordinary furnaces. The operation is continuous and furnace emptied once a week.

After a charge has been worked down to desired percentage of carbon, the slag is poured off and about 50 tons of steel poured into ladle, recarburized and casted. The remainder is treated with iron ore and limestone to produce a highly basic and highly oxidized slag. Through this slag is then poured 50 tons of molten pig. A vigorous reaction between the pig and iron oxide in the slag causes the silicon and manganese to be acted on immediately, then the phosphorus and carbon worked down in usual way. This operation is continuous and at end of six hours the bath again being purified is again tapped.

RECOLLECTIONS OF FITTIG AND THE STRASSBURG LABORATORY.

By Nicholas Knight,
Cornell College, Mount Vernon, Iowa.

In the year 1835 three children were born in Germany, each of whom was destined to achieve a high position in the field of organic chemistry. These were Johannes Wislicenus, born June 24 of that year, and died December 5, 1902, professor of organic chemistry and director of the laboratory at Leipsic; Adolf von Baeyer, born on November 30, occupying a similar position at Munich whose seventy-fifth birthday has recently been celebrated and who is still at the head of the chemical department; and Rudolph Fittig, born December 6, 1835, and died November 19, 1910, lacking only a few days of the ripe age of three-score and fifteen years. He was professor of organic chemistry and director of the Strassburg laboratory. Surely nature was lavish in 1835 in furnishing with such a galaxy of brilliant stars three of the great German university laboratories; for these three men contributed largely to the development of organic chemistry and to making the last half of the century glorious in its wonderful scientific achievements.

The chemical laboratory of Strassburg, a three story building of light-colored sandstone, was constructed in 1885 from Fittig's own plans. It is one of the most convenient and best appointed of all the great buildings devoted to chemical science. At each extremity is a private laboratory, one of which was occupied by Fittig, and the other by Professor F. Rose, the head of the inorganic division. Rose long enjoyed the reputation as the best analyst in the German empire. For many years he had worked as assistant to Bunsen, and he used many of the methods he had acquired from the great master.

Rose was kind and amiable in disposition, modest and unassuming in manner. All felt the power and influence of his great learning. He had traveled extensively in Europe, and he could speak French and English almost as fluently as his mother tongue. He was peculiar in that he never published anything, and this kept him from becoming as widely known as he was entitled to by his great ability and attainments.

Besides Fittig and Rose, two adjunct professors, four assistants, and four servants looked after the interests of the chemical department. The majority of the students naturally were

Germans, but there were also Austrians, Swiss, Italians, Belgians, Englishmen, Scotchmen, and Americans. Some of these peoples had only one representative.

The writer was enrolled as a student in the department during the years 1892-94. Fittig impressed one as a person of unbounded energy and tireless industry. A self-made man, the son of a baker, he seemed to have those qualities of character and intellect which would have made certain his success in any calling. He had been a student and assistant of Wöhler, who in turn had sat at the feet of Berzelius, the first to give instruction in a chemical laboratory. Thus he was respectably connected from a chemical standpoint. He frequently revised Wöhler's text-book in organic chemistry.

The fifty-eight years of Fittig's life rested lightly upon him, and he walked with the agility of a youth of twenty. On entering the door of the laboratory, he could usually tell at a glance on what the student was employed, and whether he was doing the work properly. His criticisms were not always expressed in the mildest possible way.

As a lecturer he was popular and was listened to by about one hundred and fifty students. He was logical and convincing. Indeed, he was considered one of the best speakers in the whole faculty. He spoke distinctly, with a peculiar drawl on polysyllabic words like *Wasserstoff and Sauerstoff*. This mannerism made him easier for a foreigner to follow, but it was a striking peculiarity, and often provoked audible smiles until the students became accustomed to it. His lectures were often enlivened by a dash of sparkling humor.

At the time of which I write, he was about finishing his work upon the dibasic unsaturated acids, especially mesaconic, itaconic, and citraconic acids, to which he had given many of the best years of his life. Arthur Brooke, a young English student, in '94 discovered a fourth isomer, which was named aticonic acid. It seemed a little late for such a discovery, when it is remembered that work on these acids was begun in 1822, thirteen years before Fittig was born. There are, of course, reasons why the acid remained so long unknown, but the details would transcend the limits of the present paper. It may be observed in passing that Fittig with his students covered this field so thoroughly that there is probably nothing left in it for future investigators. When aticonic acid was first made and identified, the interest and enthusiasm among the students who had followed

the history of the investigations could scarcely have been greater if a new world or a new continent had been discovered.

It was a pleasure and an inspiration to come in contact with Fittig in this field, especially as one realized he was the greatest authority on the subject, and that probably no future investigator would surpass or equal his knowledge in this particular department.

In the autumn of 1894, he was honored with an invitation to Berlin by the German Chemical Society to give an account of his investigations in the unsaturated acids. The full text of the address was published in the *Berichte,* and constitutes an interesting chapter in chemical literature.

Many students whom he trained have attained to eminence as scientists. Examples are President Remsen in our own country, Sir William Ramsay in England, and men equally renowned in Germany and other lands.

As one after another of the great organic chemists of the glorious nineteenth century joins the "silent majority," the question forces itself upon the attention whether men of equal caliber and ability are coming forward to take the places made vacant. The future only can make answer.

"The institution that does not reach every possible student is disloyal to civilization. I know of no more effectual way of bringing up country life or any other life than to make war on absenteeism from high school and college, provided these institutions are made equal to the opportunities at their doors."—Ashland D. Weeks, North Dakota Agricultural College.

National meteorological work in Chile has recently been completely reorganized, and Dr. Walter Knoche, late of Berlin, has been selected to direct the new Instituto Central Meterologico y Geofiscio de Chile, with headquarters in Santiago. This institution has taken over the work in meteorology and weather forecasting heretofore carried on by the Observatory of Santiago, and on January 1st, 1911, will also annex the meteorological service on the Chilean coast, which is now under the administration of the navy.

Much has been published from time to time about injurious effect of ultra-violet rays from electric lamps. This effect has been undoubtedly greatly exaggerated, particularly as the glass globes of the lamps intercept most of these rays. It was recently pointed out by Professor Gariel, of Paris, that the glare of artificial light has done far more to injure the eyes that the ultra-violet rays that emanate from them. He classes the carbon arc lamp as the worst offender in this particular, and emphasizes the importance of using shades which will not only intercept the ultra-violet rays, but will so diffuse the light as to protect the eye from bright spots of dazzling intensity.

AN EXPERIMENT ON METHODS OF TEACHING ZOOLOGY.[1]

By J. P. Gilbert,

Supervisor of Practice Teaching, School of Education, University of Illinois School, Urbana, Ill.

For a long time there has been much discussion as to the relative merits of pure science and applied science in education. Probably all would agree that applied science would best influence the later economic adjustment of the individual. Yet there are many who contend that applied science would result in a distinct loss to education, a loss which would show a marked deficiency in culture. This view is strongly maintained in an article in a recent number of *Science*. The contention is stoutly denied, however, by those who favor a maximum amount of applied science in the curriculum. In so far as I have been able to learn, the arguments pro and con have been purely mental exercises worked out in the study without any data or experimentation on which to base such philosophy.

In these arguments there must always enter the inseparable question of the relative merits of the pure science and the applied science methods of approach in the teaching of secondary school science. The present study was undertaken to determine the relative merits of these two methods of approach to the study of secondary school zoölogy. The effort was made to contribute some definite and tangible data as to the effect of these two methods of approach, not upon the economic adjustment of the pupil, but rather upon the disciplinary or cultural outcome of his science work.

A summary of results at the very outset may be helpful in enabling you to hold in mind the cardinal points of the discussion. This experiment was reported in the June number of the *Journal of Educational Psychology* and I shall quote very freely from that report.

Summary of Results.

1. The results are only suggestive, in view of the small number of individuals tested. Even allowing for the probable error, however, the applied science method of approach to the study of secondary school zoölogy appears to have a slight advantage over the pure science approach, when tested by examination

[1]Read before Biol. Sec., C. A. S. and M. T. at the Cleveland meeting.

grades (the examination being of the pure science type). When tested by average semester grades, the applied science approach shows a somewhat greater advantage. When tested by the per cent of pupils averaging more than eighty-five per cent in the semester's work, the applied science approach has a slight but appreciable advantage.

2. When tested by the ability of the pupils to set up experiments and interpret phenomena (a cultural and disciplinary standard), the applied science approach has a decided advantage.

3. When tested by the interest aroused as revealed in the voluntary "outside" reading of the pupils, the results are uncertain.

4. The method of investigating class room problems by comparing the progress of parallel groups of pupils promises to yield valuable results, but it should be carefully studied, and its technique refined through repeated tests.

Methods and Results.

The method of conducting the experiment, by the use of parallel groups (employed perhaps most notably by Winch in his memory investigations), is comparatively new, and should prove of service in questions of method of teaching such as the one under consideration.

The experiment was performed in the academy of the University of Illinois during the first semester, 1909-10. Two section of the class of beginners in zoölogy were used. These sections were approximately equal in size. They used the same laboratory and apparatus, the same text-books and laboratory guides, and were both taught by the speaker. The same subject matter was covered, and the same examination questions and tests were given to both groups. No selection of students for either section was attempted. Furthermore, the students were not informed of the experiment either upon registration or during the semester. They could not, therefore, choose one section or the other because of individual preference.

The data summarized below seem to indicate that the two sections were fairly equal with respect to distribution of sex, age, former environment, and professional bent. In computing the averages one student (forty-two years old) was not considered.

Number in Sections:

A, 17.
B, 15.

Distribution as to Sex:

A—boys, 15; girls, 2.

B—boys, 13; girls, 2.

Age:

Average age—A, 18.7 (average variation, 1.0).

B, 19.1 (average variation, 1.7).

Fathers' Occupations:

A—agriculture, 6; medicine, 1; other occupations, 10.

B—agriculture, 6; medicine, 0; other occupations, 9.

Students' Former Occupations:

A—4 have worked on the farm; 5 in other occupations.

B—4 have worked on the farm; 5 in other occupations.

Students' Intended Occupations:

A—agriculture, 1; medicine, 3; other occupations, 13.

B—agriculture, 0; medicine, 2; other occupations, 11; undecided, 2.

Throughout this report the so-called cultural and disciplinary group is known as Section A. The enrollment was 17—15 boys and 2 girls. It recited from 8 to 10 a. m. The so-called economic group is called Section B. The enrollment was 15—13 boys and 2 girls. It recited from 11 a. m. to 12 m., and worked in the laboratory from 1 to 3 p. m. It should be noted that Section B recited at a period of the day not so favorable for the best work as that used by Section A. (Cf Burgerstein and Netolitzky: Handbuch der Schulhygiene, Jena, 1902, p. 572.)

A brief statement of some of the differences in approach and treatment of some topics used will best explain the method of conducting the experiment.

Illustrative Details of Methods of Instruction.—In studying the mouth parts of insects, Section A inquired as to the significance of these structures and adaptations in enabling the possessor to maintain its existence and be successful as a living creature. Section B made the same inquiry, but dwelt upon this significance for a shorter period and asked at some length the economic importance of these structures and their adaptations to the destruction of crops and property and to the spread of disease.

Section A visited a market garden and found aphids upon the vegetables, particularly upon cabbage plants. They studied such points as the great numbers, wide distribution, rapid multiplication, suctorial mouth parts, parthenogenesis, etc., of these creatures as factors which make them successful as a species. Sec-

tion B found the same aphids and discussed the same points more briefly. They then considered the extent of the injury done in the garden and how parthenogenesis, rapid reproduction, and wide distribution of aphids contribute to the destruction of vegetables and other crops. Section A discussed the sucking mouth parts of aphids, squash bugs, and other Hemiptera as adaptations which enable these insects to employ a particular method of obtaining food from beneath the epidermis of the food-plant or animal. Section B noted the same points, but gave considerable time to a discussion of the fact that this particular type of mouth parts is responsible for the very large number of exceptionally injurious species to be found in this order, such species, for example, as plant lice, scale insects, squash bugs, cicadas, chinch bugs, bed bugs, etc. In this connection it was pointed out that the arsenical stomach poisons used effectively against the Colorado potato beetle and similar insects with biting mouth parts are of little service against this group with beaks which may pierce the epidermis of the plant and suck the juices from beneath the coat of poison. Therefore, if the Hemiptera are to be destroyed artificially, it must be in some other manner, as by contact poisons in the form of washes and sprays, or by the fumes of poisonous gases. It is manifestly far more difficult to place poison in contact with each individual insect than to spread it upon vegetation where biting jaws would devour it. In the study of the mouth parts, then, the economic section saw a partial explanation of the large per cent of Hemiptera which are both injurious and difficult to control. This discussion was followed by a brief study of methods controlling injurious Hemiptera.

Section A observed the lady-bird devouring aphids to satisfy its appetite and maintain its existence. Attention was called to the fact that the little insect gives off a fluid which is distasteful to birds, toads, etc., which might otherwise feed upon it. The class observed that the lady-bird is conspicuously marked, and, remembering that it is unpalatable, concluded that this might well be considered a warning coloration. Section B noted the little beetle devouring aphids, and, knowing the harm done by plant lice, at once concluded that the lady-bird is exceptionally beneficial to man. They discussed, also, the bad tasting fluid which repels enemies, and noted the conspicuous color, but looked upon these provisions as fortunate means of protecting the very valuable little creature from destruction by predaceous animals.

Section A found tomato worms and noted their food, their color

corresponding to the foliage, their means of holding on to the stems, the parasitic Hymenoptera emerging from the caterpillars, and the weakened condition or death of the tomato worm as a result. Section B noted all these points, but estimated the damage done to the patch of tomatoes, figured the per cent of parasitized forms, and concluded that a very large per cent of these insects are killed by the parasite, and that the ultimate damage done by them is perhaps correspondingly diminished.

The tongues of the frog and toad were discussed by Section A as organs especially adapted in point of attachment and in structure for obtaining insects used as food. Section B looked upon the organ as one not only enabling the toad to get its own food, but also as one which fortunately enables the toad to perform great service to man by destroying injurious insects on farms. Section A observed the extensible horny-tipped tongue of the woodpecker as a structure used to spear and extract the grubs from the trees after the chisel-like beak has made the opening in the bark. Section B saw in this structure a means not only of obtaining food for the bird, but also a means of saving our forest and fruit trees from grub and borer injury to the amount of many million dollars annually.

Section A discussed bird migration, noting its causes and its effects upon the bird population of the region and upon the species migrating. Common birds were classified as permanent residents, summer residents, winter residents, transients and accidental visitors. Section B discussed the effect of migration upon the food of the bird, and on the insects and weed seeds destroyed in a given region. If a bird's food habits are good, it is most beneficial in the locality if it resides there permanently. It perhaps is of next greatest value if it is a summer resident and nests in the locality. This is particularly true since young birds are so frequently fed upon injurious caterpillars and grubs. Each group of migrants was discussed with reference to the value of its individuals in an economic way. To Section B this classification meant in part, that a bird was of greater or less value on the farm and in the forest accordingly as it fell into one or the other of these groups.

In like manner Section A learned the distribution and number of birds in pastures, plowed fields, forest, etc., where they obtain the particular foods they most desire. Section B learned this distribution and asked what significance it might have in holding in check the particular destructive insects found there.

The preceding examples, while not given in great detail, will indicate some of the differences in points emphasized in the two sections.

Methods of Testing.—Perhaps few experiments are more complicated than the one here undertaken. Numerous factors enter into the results, and some of these factors are not easily controlled. For example, by reason of previous training or occupation some students in Section A may have developed strong economic tendencies, which might easily serve as a source of interest in the study of biological forms. This would tend to minimize any real advantage gained by the economic section. Furthermore, much difficulty was experienced in the development of a technique. In fact, the solving of problems of method rather overshadowed the obtaining of definite data, and must continue to do so, in a diminishing degree, until the method of attack is perfected.

Results were compared mathematically upon:

1. The amount of zoölogical knowledge assimilated.
2. The power to set up simple experiments and to interpret phenomena.
3. The interest of the sections.

The Examination Test.—The amount of knowledge assimilated was tested in the usual way, by written examinations, the same questions being given to both sections. Every effort was made to avoid the economic element in the questions asked so that Section A would be under no disadvantage. The questions were made to cover the field of study pretty generally and to search the ground rather thoroughly. The final examination questions will serve as a type and were as follows:

1. Define the following zoölogical terms, and give an example of each: mimicry, homology, analogy, instinct, intelligence, parthenogenesis, exoskeleton, endoskeleton, vertebrata, imago.

2. Discuss the relation of insects to disease.

3. Discuss the relation of insects to flowers. (Omit discussion of the milkweed studied in the laboratory.)

4. Give the life histories of the mosquito, the housefly, and the frog.

5. Define evolution, natural selection, hybrid, dominant. State Mendel's law of heredity as it applies to white and gray rabbits.

6. Compare the respiratory and circulatory systems of the locust, the crayfish, the frog, the bird, and the rabbit.

7. Give characteristics and examples of: Orthoptera, Odonata, Hemiptera, Coleoptera, Diptera, Hymenoptera.

8. To what class and order does each of the following animals belong: Ostrich, owl, bob-white, cat, horse, crayfish, green-frog, butterfly, black-snake, man?

9. Define carapace, cephalothorax, somite, exopodite, palpus, metathorax, ocelli, gastric mill, cheliped, cerebrum, amoeba, arthropoda.

10. What animals can you find abundant in the fall in cabbage fields and gardens, in weed and stubble fields, in stagnant, filthy water, such as that near the Smith Packing House, in the dredge ditch, in a dusty road? (Recall your field trips.)

Results of the Examination Test.—The examination papers were numbered and the grades recorded before the names of students holding these numbers were known to the instructor. This was, of course, done to eliminate the personal equation in judging results. Section A made an average grade of 72.5 per cent in the final examination, while Section B made an average grade of 73.2 per cent.

Results of Comparing Semester Grades.—The average semester grade for all subjects other than zoölogy of the students in Section A is 80.35 per cent. In zoölogy the average of the same student for the semester is 81.53 per cent. The average semester grade of the students in Section B in all subjects other than zoölogy is 78.47 per cent. In zoölogy their average for the semester is 82.73 per cent. Section A, then, has an average in zoölogy which is 1.18 per cent higher than their average in other subjects. Section B has an average in zoölogy which is 4.26 per cent higher than the average in other subjects. In all subjects other than zoölogy Section A has an average which is 1.88 per cent higher than that of Section B. In the final examination, however, Section B has an average grade which is 0.7 per cent higher than that of Section A. After calculating the probable error in all the data obtained, a very slight advantage appears in favor of the economic approach. While this advantage is too small to warrant any final conclusions upon a single trial of the experiment, it does warrant the conclusion that the experiment is worth repeating with the hope of obtaining more conclusive data as the technique is perfected.

Results of Comparison of Pupils Averaging Over 85 Per Cent.—Viewed from another standpoint, the grades are even more in-

teresting than is indicated above. The per cent of students making above 85 was 29.4 in Section A and 46.6 in Section B. The per cent making from 75 to 85 was 41.1 in Section A and 33.3 in Section B. The per cent making from 70 to 75 was 23.5 in Section A and 13.3 in Section B. This seems to point to a rather clear advantage for Section B. However, if this advantage exists in a rather marked way as indicated in these figures, it may be asked why the average of Section B is so little above that of Section A. The fact of the matter is that in Section B there was a case of premature love-sickness, a thing which high school teachers will admit is difficult to control so long as the parties are thrown together in the class. Perhaps no method of presenting subject-matter will greatly influence such cases. These two students materially lowered the average of Section B.

Frequency curves (not published in this preliminary report) were plotted both for the examination grades, and for the pupils averaging over 85. They show a uniform advancement of the "stations" of the various groups of Section B, as compared with analogous groups in Section A, while the frequency curves for grades in other subjects show the inverse relation.

The Test for Ability in Experimentation and Interpretation: Its Results.—The following is an example of the method used to test the ability of students to set up experiments and interpret phenomena. The supply table was provided with all necessary containers and apparatus for transfer of materials; with thermometers, food materials, etc., for the experiment. Mosquito larvae of uniform age and size were placed on the table, and the classes were directed to determine by experiment the effect of abundance and scarcity of food supply upon the rapidity of growth and development of mosquito larvae. The individual student was then required to write out a detailed account of the steps to be taken and present this for approval. This precaution prevented the possibility of students getting suggestions by seeing other students at work on the same problem. Defects such as failure to specify that the containers in the experiment must be placed under the same temperature and light conditions were checked against the student, and he was required to make a second report. Of students in Section A, 35 per cent reported correctly on the first trial, and 47 per cent more were correct on the second report. Of students in Section B, 60 per cent reported correctly on the first trial, and 33 per cent more were correct on the second trial.

This gives an advantage on first reports in favor of the economic section.

The Test for Interest and Its Results.—As to interest, while the speaker is confident that much the greatest advantage in favor of the economic section was found here, he does not care to represent this difference in mathematical terms until he has better control of some of the factors involved. Readings from Burroughs, the Peckhams, Darwin, Huxley, Wallace, De Vries, Jordan, Kellogg, etc., were assigned to Section A. Reading from numerous bulletins from the Department of Agriculture at Washington and from the state experimental stations were assigned to Section B. Records of voluntary readings by the two sections were somewhat vitiated by the fact that books wanted were frequently in use by other departments of the University. Figures are, therefore, not given on this point. Interest, however, both in the regular class work and discussions and in the outside work seemed to be greater in the economic section and it was here that the results seemed to be most favorable to the economic approach. More definite and reliable data can be obtained on this point in future experiments.

Conclusions.

One chief concern of the speaker in performing this experiment was to satisfy his own mind as to the feasibility of getting data of real value by this method of experimentation. The only definite conclusions which the experiment justifiies are that the method, with such modifications as experience will bring, can be applied successfully, and that the problem of the relative merits of methods of approach to zoölogy is worthy of serious consideration and experimentation.

The speaker is also very anxious that other teachers interested in this type of pedagogical problem should try the method here suggested, and that they should contribute first to the development of the needed technique, and finally to the determination of the relative merits of pure science and applied science in education and of the best method of approach to the study of biology.

The experiment was continued during the second semester of last year upon two sections of beginners in botany. Since registration resulted in mixing students from the two zoölogy classes and since, also, the botany classes became the dumping ground for students who had failed in the first half of various one year courses, I do not feel justified in giving very much weight to the

results of this additional test. I should say, however, that the results are even a bit more favorable to the economic approach than was the case in the more reliable data of the first trial of the experiment.

During the present year I am continuing the experiment in zoölogy, giving an entire year to the subject instead of the course for one semester of last year. This will make possible a more careful and more efficient test of results.

You will note that mention has been made only of the effect of this experiment upon the student. Professor S. A. Forbes, state entomologist of Illinois, so forcibly focused my attention upon an additional point, that I must include it in this discussion. This point is the effect which such experimentation has upon the teacher. I quite agree with him that the teacher with such an experimental end in view will bring greater efficiency into the teaching of all his classes. The attention of the experimenter must be focused upon the purpose of the course and the parts of the course, and a clearer definition of the ends to be attained is inevitable. We are told that a most serious defect among teachers is that most of them are unable to tell, with any degree of clearness, what they expect to accomplish with the particular course or the particular subject matter they are presenting. Such an experiment as here undertaken would go a long way toward eradicating this evil and toward enabling the teacher to organize the course toward the attainment of some definite goal to which he might lead his pupils.

Every observer knows full well how the great majority of students proceed to forget nearly all their secondary school science in a remarkably short time. I hope to devise means of testing some of these students to determine which group of students remember the subject better. This will manifestly be difficult and possibly not entirely reliable, but I believe that it can be made to throw some valuable light upon the question at issue.

In former discussions those who advocated applied science have been forced to take the defensive. While the data here obtained do not finally settle the question of the relative merits of the pure science and applied science approaching to secondary school zoölogy, they do shift the burden of proof to those who advocate the cultural approach.

Dr. W. C. Bagley, Director of the School of Education of the University of Illinois, approved the plans of the experimenter, and he gave much encouragement and helpful advice which were of

great value in the effort to solve this difficult problem. Working conditions are not of the best in the academy where this experiment is being made, and some improvements have been withheld because the academy is to be discontinued at the close of the present academic year. The Legislature of the state will be asked to establish a model high school as a part of the School of Education, using the present academy as a basis.

THE PHYSICAL VERSUS THE HUMAN SIDE OF PHYSIOGRAPHY.[1]

(ABSTRACT.)

BY GRACE ELLIS,
Grand Rapids, Mich.

The purpose of physiography is first of all to educate the pupil, just the same as any other subject. Physiography is perhaps an uncommonly good subject for a pupil to learn to think straight through a problem, and to talk to the point. While he is doing this he may well learn proper methods of study; how to study, how to work; how to reason from one thing to another; to get his data first, and get all the available data on the subject, and from them to form his conclusions; and not to make conclusions too big for his data. It makes for intellectual honesty to reason straight.

If you can at the same time get students to see the partialness of many conclusions, they reach a point where they do not necessarily want a yes or no; but may work for the truth, for the sake of what may be done with it.

There are no dull moments in a subject which may at any time turn up a fact which affects you even remotely. The results of the cutting of valleys in strata of horizontal rock is a very different thing when the theory of the book is to be applied to your own river, in your own home, and the power it develops and the flour mills it can run. Latitude and day length are vital when it is they which determine whether or no the wheat to supply these mills can be raised in your vincity.

When the fundamental facts of any section of the subject have been learned, then they should be applied to the place the child knows most about, if such application is possible, and their bearing on human life made evident.

[1]Read before the Earth Science Section C. A. S. and M. T., Cleveland, 1910, meeting.

The geographic influences in the development of the child's home; the position of a trading post on an old Indian portage; the subsequent development of trade and the growth of the city —all this is of absorbing interest to the child. From the geographic influences in the development of his own home he works out to the broader influences of geography on history.

Water gaps open a way to discuss the strategic importance of the Blue Ridge gaps and the Shenandoah Valley, and it is not hard to show a boy why the "Shenandoah Valley was a pistol pointed from the Confederacy toward Washington."

One might illustrate at any length, but the real meat of the matter is, it seems to me, the possession of the fundamental facts; the development of power to apply them, and an unclouded intellectual honesty.

Discussion By Geo. D. Hubbard, *Oberlin College, Oberlin, O.*

The key to geography is the relation of the life element to the environment, the organic to the inorganic. This puts the emphasis on the life and on the human element. The method of approach is through the human interest.

The question for us here then is how can high school geography best sustain this point of view and at the same time make use of the pupil's elementary training.

In the grades the theme has been political geography and the unit, the nation or state. Physical geography has been introduced by description. When our pupil is through the high school we want him to have a sympathetic and informing knowledge of the regions of the world, which will help him to appreciate national and race differences, to understand something of the reasons for differences in production, and diversity of industrial development and the consequent necessity for commercial enterprise. We want him not only to grasp the fact of our interdependence but also to see the reasons for it and respect them. In this the human element is decidedly the most important.

A high school course then which gets together and organizes what physical geography the pupil has had, and adds enough to make him appreciate topographic and climatic diversity and the distribution of types of features, and gives him the fundamentals of the reasons for both diversity and distribution, and at the same time (in the same lesson day by day) teaches him the uses of the diverse features of land, water, and air, their influence on life in general and on man and nations in particular, is the course which may best meet his needs.

THE NEED AND SCOPE OF A FIRST YEAR GENERAL SCIENCE COURSE.[1]

By R. O. Austin,
High School of Commerce, Columbus, O.

The term general science as here used is understood to mean a course made up of material from the different sciences brought together and treated in a manner suited to an elementary introduction to science study.

It is not the idea, however, to select bodily certain chapters from the various sciences and form them into a single but desultory course. Let the material be selected with some idea of unity and with some definite ends in view. Let it consist of some of the most fundamental things in science and certain of those principles which have most practical application in everyday affairs, or which are of the most importance in preparing for further science study.

It must not be thought therefore that this is some new field of science recently discovered and introduced just now for the first time. It must of necessity consist mainly of physical, chemical, and biological science, but every effort must be made, however, to give new treatment to the old subjects and to enrich and enliven them by emphasizing the attractive or even spectacular features.

It is true that some of the most common phenomena are the most difficult of explanation, and it is not claimed that *every* important principle can be illustrated in an easy and attractive way to lead the student over some royal road to science; but it is certain that out of the abundance of material enough may be selected that *is* within his comprehension to serve the purpose of the course and amply justify its introduction.

Our science work has been too serious and rigorous, too much of a task. Let it unbend and have more fun. To bring this about is one of the aims of the course in question. If the course does not awaken in the pupils a desire for more science, then it has been improperly taught and has fallen short of its purpose.

It is likely that some one of the sciences should predominate, but opinions differ as to which should be made the basis of the course. The majority of teachers will probably agree that physics and chemistry are fundamental sciences, and that they should therefore constitute a large part of this course. Different teachers

[1]Read at Cleveland meeting Central Association Science and Mathematics Teachers.

will differ in their choice of fundamentals. The geography teacher will emphasize that part of physics and chemistry which does most to explain the phenomena of meteorology, climate, soil formation, and related subjects. The biology teacher will select those topics which contribute most to the explanation of the life processes of plants and animals.

It must be kept in mind that young persons are interested not so much in the theory and abstract philosophy of things as in the illustration of everyday phenomena. The material must therefore come largely from the industrial world and the field of household economics.

In any event the course must be *distinctly experimental* and inductive, and it must be conducted in the laboratory where pupils are in the midst of things and are thrown upon their powers of observation. The instructors must be teachers of experience in laboratory work and skilled in demonstration. They must give the class their best efforts and make the experiments speak for themselves. Here more than in senior subjects must the experiments be convincing.

Any course that does not give the pupils some individual laboratory work falls short of its greatest possibilities. However, for lack of equipment and facilities not many schools will be able to give the pupils very much individual work. In either case let the experimental work be qualitative and the amount of mathematical data recorded reduced to a minimum. The course must strive constantly to acquaint the pupil with the everyday things of life and give him an insight into some of the phenomena immediately about him.

I believe, therefore, that the course should consist largely of the material commonly studied in physics and chemistry, and especially of those principles and conditions that find application in everyday common affairs and in other fields of science. For example, diffusion or osmosis is illustrated by experiment as a force or property of matter, but its occurrence as a process of nature is met in botany and physiology. The limewater test is studied and learned in chemistry and the student is prepared to use it as a tool in the study of respiration, ventilation, fermentation, etc. I believe that these important fundamental principles should be studied first by themselves on their own merits and not held in reserve until met in their applied form as occurring in the processes of nature. Some teachers, however, would prefer the other plan and hold the limewater test until needed in respiration. Physiology

would be temporarily put aside and chemistry taken up to the extent of learning the limewater test. Rather let these fundamental principles be learned by themselves and when met in the applied form the student may use them as tools in the same way that he uses algebra in higher mathematics.

At present general science as a course of study is in its experimental stage, and it is found only in a comparatively few schools. It is, however, quite common in New England, especially in Massachusetts, where it is limited mainly to physics and chemistry, and where its aim is not so much to prepare for further study of science as to furnish an elementary course in physical and chemical science complete in itself and resting upon its own merits. At Springfield, Mass., it has perhaps reached its highest development where it is furnished with extensive equipment for elaborate demonstration work.

At Columbus, O., elementary science is studied for the first three months of the first year followed by physical geography during the remainder of the year. The course is mainly physics and chemistry and their applications to physiography, the preparation for which is its chief aim. The course has been more or less varied because of the attitude of the geography and other science teachers, the latter wishing to see it widened in scope and given more time, and the former fearing that it will intrude too much upon geography. It is, however, looked upon with favor by all who have been connected with it to the extent that it is considered a settled and indispensable part of the curriculum.

At Oak Park, Ill., the subject is given an entire year. It is built about a well-selected list of experiments that lead up to physiology.

The University of California has recently recommended general science for the first year of the high school, and a number of schools have already adopted the suggestion.

It will be seen therefore that there is quite a wide divergence of opinion as to what the course should comprise, and as to what should be its chief aim—whether for the science knowledge alone or for preparation for other science study.

In order to be more explicit and put us all on more common ground I beg to offer the following outline as suggestive of a course in general science that may be extended over a year or condensed to half a year.

Outline of a General Science Course for First Year High School.

I. Some Physical Properties of Matter.

1. States of matter, constitution of matter. Experiments in impenetrability and weight of air; diving bells, and caissons for work under water.
2. Inertia—Experiments and illustrations. Starting and stopping of the train, collisions, railroad curves.
3. Elasticity and compressibility of air—compressed air fountain, popgun, bicycle pump, riveting hammer, compressed air engine.
4. Porosity of wood, soil, and rock, filtration, oil and gas bearing rocks.
5. Crystallization—blue vitriol, potassium bichromate, alum basket, salt cubes, rock candy. Water of crystallization. Crystallization in nature. Amorphous and crystalline substances—starch and sugar.
6. Diffusion in liquids and gases—osmosis and its application in botany and physiology. Non-diffusible substances—mercury, water, and oil.

II. Forces.

1. Adhesion and cohesion—water and glass, glass plates, welding.
2. Capillarity—experiments with glass tubes, water, mercury, oil, candle, blotter, lampwick. Creeping solutions—sal ammoniac. Capillarity in botany and physiology.
3. Surface tension—water and mercury surfaces, soap bubbles, oils and camphor gum on water. Globular form—shot, water drop, mercury, planets.
4. Centrifugal force—illustrations and experiments. Sling, flattening of the earth, gyroscope, saucer bicycle track, loop-the-loop, motion of the planets. Industrial applications—laundry and creamery.
5. Gravitation and gravity.
6. The lever principle and its application in the bones of the body.

III. Chemical and Physical Phenomena.

1. Chemical and physical changes—combustion, solution, filtration, evaporation, precipitation, sodium and potassium on water—alkalies. Elements and compounds. Study of carbon, sulphur, and phosphorus.
2. Acids, bases, and salts. Action of sulphuric, hydrochloric, and nitric acid on wood, cloth, and paper. Litmus and neutralization. Ammonia test for hydrochloric acid. Limestone test. Removal of plaster from floors.

IV. Study of Oxygen.

1. Generation, tests, properties, occurrence in nature, natural and artificial uses, relation to plants and animals.
2. Necessity of oxygen for ordinary combustion.
3. Function of oxygen in respiration; oxidation and animal heat; oxygen and life.

V. Hydrogen.

1. Generation, tests, and properties.
2. Formation of water. Explosive mixtures.
3. Artificial uses—oxyhydrogen flame and blowpipe; calcium light, balloons, illuminating gas.

VI. Water.

1. Electrolysis and testing of the products. Symbols and formulas.
2. Forms of water.
3. Water of crystallization.
4. Boiling point, freezing point, and temperature of greatest density.
5. Expansion of water when changed to ice and the economic value of this.

6. Natural waters—soft and hard. Incrustations in tea-kettle. Boiling of soft and hard water for deposits.
7. Filtration and distillation in the laboratory. Separation of alcohol and water.
8. Water supply of cities—reservoir system, stand pipe system, and engine pressure system.
9. City filtration and purification plants.
10. Air in water. Running and sluggish water.
11. Medicinal waters and mineral springs. Testing of water for iron compounds.

VII. Nitrogen.

1. Preparation, tests, and properties. Comparison of oxygen and nitrogen.
2. Approximate proportion in air and uses.

VIII. Carbon Dioxide.

1. Preparation in the laboratory.
2. Chemical and physical properties. Density shown by pouring over candle flames.
3. Occurrence in air and formation in nature.
4. Lime water test and comparison of quantity in the breath and in other air. Carbon dioxide from the combustion of wood.
5. Testing of air in room for carbon dioxide.
6. Effervescence—testing rocks and shells for lime stone. Soda water.
7. Relation of carbon dioxide to plant and animal life. Exhalation of carbon dioxide by animals and of oxygen by plants.

IX. Air Pressure.

1. Air pump and bladder glass. Ground edge tumbler. Vacuum and vacuum cleaners.
2. Water and mercury barometer. Reading of barometer. Pressure curve. Weight of air and water. An atmosphere.
3. Aërial ocean and water ocean. Compressibility of air and water.
4. Uses of the barometer. Aneroid barometer.

X. Pumps, Siphons, and Springs.

1. Glass tube and piston—water pump. Examination of kitchen pitcher pump.
2. Siphon and uses. Separating milk from cream and water from sediments.
3. Water level, springs, and artesian wells.

XI. Buoyancy and Specific Gravity.

1. Floating and sinking bodies.
2. Specific gravity of heavy bodies.
3. Hydrometer and lactometer.
4. Buoyancy of gases—balloons and air ships.
5. Exploration of upper air.

XII. Heat.

1. Sources.
2. Measurement of temperature—thermometers.
3. Some effects of heat—expansion in solids, liquids, and gases. Force of expansion—steam and its application.
4. Irregular expansion of water and its valuable economic consequences.
5. Change of volume during fusion—bursting of water pipes.
6. Evaporation—effects and uses, cooling by evaporation; evaporators and vacuum pans.

7. Boiling point of water and alcohol.
8. Relation of boiling point to pressure. Culinary applications.
9. Boiling point of solutions.
10. Boiling point in engine boilers.
11. The calorie and specific heat. Comparative time required for heating water and other substances; for example, alcohol.
12. Latent heat of fusion and evaporation.
13. Water as a heat reservoir and effect of large bodies of water on temperature.
14. Land and sea breezes.
15. Artificial cold—solution, evaporation, expansion. Experiments with compressed carbon dioxide. Manufacture of ice.
16. Conduction in solids, liquids, and gases. Davy's safety lamp. Conductivity of the ground. Cotton and woolen clothing.
17. Convection in liquids and gases—Hot air, hot water, and steam heating of buildings—Ventilation. Model of furnace.
18. Trade winds.
19. High and low pressure areas.
20. Radiation.

XIII. Hygrometry.

1. Humidity and dew point. Relative humidity, dew, rain, fog, clouds, weather bureau indications, use by pupils of instruments, observations, curves of temperature, humidity and pressure.

XIV. Magnetism and Electricity.

Needle, earth, compass, frictional electricity, Leyden jar, lightning.

XV. Current Electricity.

Batteries, electro magnets, electric bell and door bell system, electroplating, electric lights.

XVI. Light.

Shadows, eclipses, reflection, refraction, prismatic colors, and the rainbow.

XVII. Household Science.

1. Reading meters and determination of amount and cost of gas, electricity, and water. Testing for quantity of gas used by hot water tank and by a single light. Curves.
2. Testing water for sewage and vegetable matter.
3. City gas systems—natural and artificial gas. Testing pressure by the water manometer.
4. City sewer system—sanitary and storm sewers.
5. Traps and vents in house plumbing system. Siphons.
6. City water supply—reservoir, stand pipe, and engine pressure system. Filtration plants. Fire protection.
7. Methods of heating buildings—hot-air furnace, hot water and steam.
8. Home and school ventilation. Testing for carbon dioxide in the air.
9. Elements and compounds in the human body.
10. Classification of foods—carbohydrates (starch, sugar, glucose), albumins, minerals, water; tests for the different nutrients.
11. Testing nutrients for solubility in cold and hot water—salt, sugar, starch, etc.
12. Occurrence of water in foods—weight before and after drying. Per cent of water in vegetables.
13. Acids, bases, and salts. Litmus tests. Testing of soap for free alkali. Testing vinegar, acetic acid, sour milk, lemon juice, buttermilk, cream of tartar, with litmus.

14. Study and testing of foods for sugar, sulphur, starch, proteids, etc. Changing of starch to sugar. Action of hydrochloric acid on nutrients. Function of the gastric juice in digestion.

15. Stains and their solvents. Use of ammonia.

16. Testing of butter. Specific gravity tests for milk and cream.

17. Study of alcoholic fermentation, yeast, molds, bacteria, sterilization.

18. Meaning of "light" and "heavy" as used in baking. Explanation of "rising." Use of soda and baking powder.

19. Bread raising—yeast rising and milk or salt rising. Alcohol and carbon dioxide.

20. Aluminum culinary utensils—their conductivity and specific heat.

21. Fireless cookers. Relative merits of the hay filled, excelsior filled, and asbestos filled boxes; tested by means of rice.

22. Gas economy—cooking potatoes in gently boiling and in violently boiling water.

23. Functions of the different foods and purpose of cooking starches, sugars, fats, albumins.

24. Food charts and food values.

25. Germination of seeds, relation of temperature, water, and air.

Such in brief is an outline of a proposed course, representing the opinion, however, of only one. Others would have it very different and in fact there would be as many courses as teachers.

The course does not contain new subjects but it is expected that the teacher will adapt the experiments to the age of the pupils and use every effort to give freshness and life to his treatment of the course.

Pupils will have no trouble in learning technical terms when the objects for which they stand are before them. The nomenclature of a science is of no small importance; without it the student is helpless. I do not believe in avoiding scientific terms by using familiar but inappropriate words. It is just as easy to teach perpendicular line as "upright line." The names in science are no harder than the names of flowers with which all children are familiar.

The topics in chemistry are placed early because the pupils are in need of the knowledge of the gases, and because physical and chemical changes must be studied side by side.

The names oxygen, hydrgoen, nitrogen, carbon dioxide, etc., are familiar to the pupils before they reach the high school, as they have both heard them used and seen them in print; but to these pupils the terms are merely empty words, names without ideas. Until the pupil has experimented with the gases and seen their properties the terms oxygen and hydrogen are mythical expressions that serve only to mystify and discourage. It is to be regretted that so large a per cent of our high school students graduate utterly ignorant of these simple things of science.

Heat is given considerable attention because of its common importance and the wide application of its principles in geography and the other sciences. The topics in heat are not difficult except those of specific and latent heat, and the only excuse for including the discussion here is their need in the explanation of the effect of large bodies of water on temperature and climate, the cooling effect of evaporation, etc.

The experimental work in home economics will appeal to the girls and do much to give dignity to home labor and to open their eyes to a realization that household affairs should be studied in a systematic and scientific manner. The ignorance of the average high school girl of kitchen affairs is a condition greatly to be deplored.

In conclusion I will summarize the reasons for the introduction of a first-year general science course.

1. To develop early in the mind of the pupil the science habit, *i. e.*, a desire to get at the cause and explanation of things and learn them firsthand—to know as a result of experiment and investigation and not merely by reading the testimony of others.

2. The pupil should not be required to wait until his junior or senior year to get this elementary science knowledge.

3. The preparation that the course gives for the other sciences makes them much more approachable, attractive, and profitable to the student.

4. Less than three quarters of the pupils entering the high school ever reach the junior year and without this course three quarters are deprived of even a glimpse of garden fields of science.

5. As the course greatly enhances the interest in science subjects it has resulted where used in greatly increasing the numbers in the other science classes.

6. The course gives early training in cultivating the powers of observation and arriving at conclusions.

7. With this course in the curriculum some of the subjects of the usual physics course can be given less time or entirely omitted, thus relieving the tension in physics and allowing more time for practical applications of the principles.

8. The laboratories are the most expensive departments of the school and it is not right that their benefits should be enjoyed by so small a number of pupils.

THE TEACHING OF MATHEMATICS IN THE PRIVATE SECONDARY SCHOOLS OF THE UNITED STATES.

(*Continued from the February issue.*)

The Course of Study.

DETERMINATION OF THE CONTENT OF THE COURSE OF STUDY.

In answer to the supplementary questionnaire, about one hundred schools gave information in regard to the control of the course of study. In ten cases the content of the course is said to be determined by college entrance requirements, and in five cases by trustees, governing board, or some outside authority. In two-thirds of the other schools, the principal takes some part in the determination of the course, usually consulting with teachers, head of department, faculty, or trustees. A head of department acts alone in fourteen schools in dealing with the content of the course. In nine schools, teachers of mathematics are free to lay out their courses of study, and in twenty-eight others they are consulted. The plan mentioned by the greatest number of schools (twenty) calls for joint action by the principal and the teachers of mathematics.

A large majority of the schools report that the director of mathematics is free to modify the course of study to suit the needs of particular classes, but the approval of the principal is frequently mentioned as a condition. College requirements are often referred to as a definite limitation upon modification of the course, and the details reported in answer to the principal questionnaire would seem to indicate that these requirements have a controlling influence in most schools. So far as one can judge from the meager comments on "flexibility of the course" the freedom of the teachers is usually limited to order of topics, proportion of time devoted to different topics, and methods of teaching. There is nothing in the replies to show that courses are shortened or changed in content to suit the characteristics of particular classes.

Teachers are commonly free to select their own text-books, although the approval of the principal or head of department is often required. In fourteen schools, books are selected by the principal and in seventeen by the head of department.

THE COURSE IN GENERAL.

Eighty per cent of the returns from the principal questionnaire report the mathematical subjects in each year of the course.

Most of the schools report no differentiation for students anticipating different vocations, but schools giving commercial courses commonly require commercial arithmetic—sometimes in place of geometry—for pupils of this department. In many schools separate sections are organized for college preparatory students, and, in some cases, particularly in the girls' schools, such students are required to take more work in mathematics than others.

With very few exceptions all students are required to study elementary algebra and plane geometry. Solid geometry is given in about eighty per cent of the boys' schools, forty per cent of the girls' schools, and sixty-five per cent of the coeducational schools. Plane trigonometry is given in about seventy-five per cent of the boys' schools, thirty-five per cent of the coeducational schools, and eighteen per cent of the girls' schools. "Advanced" algebra is given in nearly half of the boys' schools, rarely in the others. Solid geometry, plane trigonometry, and advanced algebra are frequently elective subjects except for students of the scientific course. They are seldom given in the girls' schools of the North Atlantic States. A very few schools give courses in spherical trigonometry, analytical geometry, and calculus.

ORDER OF SUBJECTS.

The most general arrangement of subjects in the four years' course is that which places algebra in the first two years, plane geometry in the third, and solid geometry and plane trigonometry in the fourth. There are, however, many variations from this plan.

Arithmetic, either alone or combined with algebra, is given in the first year in about one-fourth of the boys' schools and coeducational schools. It is given less frequently in the girls' schools.

Plane geometry is frequently placed in the second year instead of algebra. In many of the boys' schools, the time assigned to mathematics in the second and third years is divided between algebra and geometry, but this practice is much less common in the other schools.

Solid geometry is sometimes given in the third year, usually as a continuation of the course in plane geometry which occupies the first part of the year. This plan is common among the coeducational schools, about one-fourth of which give no mathematics in the fourth year.

The final year of the course is characterized by much variation. Several schools for girls and for both sexes give courses

in practical arithmetic. Some schools defer plane geometry until this year and others give a second course in elementary algebra or a combined course in algebra and plane geometry. About one-third of the girls' schools report courses for review of algebra and plane geometry which are usually required for college preparatory students.

Schools which give solid geometry, trigonometry, and advanced algebra usually assign these subjects to the final year.

CONTENT OF COURSES IN THE VARIOUS SUBJECTS.

The principal questionnaire called for a detailed description of the course of study by references to text-books with comments indicating departures from the order or scope of the books referred to. This part of the questionnaire brought the least satisfactory returns. In many cases no information was given, and in others it was obviously incomplete. About forty per cent of the returns, representing about one hundred and sixty schools, indicate the scope of the courses. This conforms so closely to college entrance requirements as defined by the College Entrance Examination Board, that reference to these definitions[11] with a few words of comment will be an adequate presentation of the data.

In algebra many of the schools reporting limit the work of the first year to the fundamental operations with integral and fractional expressions, factoring, and the solution of linear equations with one or more unknowns. Others cover all the topics included in the "Board's" definitions of "Algebra to Quadratics," and a few give still more advanced work. The complete course in algebra as reported by some schools is more comprehensive than the definitions, including some or all of the following topics: inequalities, imaginaries, variation, harmonical progressions, infinite series, undetermined coefficients, logarithms, probability, continued fractions, summation of series, exponential and logarithmic series, theory of numbers.

In geometry and plane trigonometry, the scope of the courses is more nearly uniform than in algebra. Nearly all the schools reporting follow the text-books closely, almost the only change mentioned being the omission by many schools of theorems on maxima and minima of plane figures. In solid geometry, one widely-used text-book adds a chapter on conic sections to the topics included in the definition of the College Entrance Examination Board, but many schools omit this.

[11]Document No. 44, College Entrance Examination Board, Post Office, Sub-station 84, New York City.

Methods.

GENERAL CLASS ROOM METHODS.

In the schools represented by the returns from the supplementary questionnaire, a part of nearly every lesson is devoted to oral recitation of the assigned lesson, but this plan is used less frequently in algebra than in geometry. In many of the schools oral drill occupies a small part of each period and in most of them, blackboard work by pupils is called for regularly. A common practice is to have half the class at the board while the other half works at seats or recites the lesson of the day. In most schools, classes are required occasionally to answer in writing questions on the assigned lesson. A new topic is usually developed in class before home work upon it is assigned.

PREPARATION OF LESSONS.[12]

The younger pupils and those whose work is deficient are in many schools required to prepare their lessons under the supervision of teachers. The older pupils in good standing generally study in their rooms, if in a boarding school, or at home, if day pupils. A few schools report a regular weekly period in which the teacher trains the pupils in methods of preparing a new lesson.

The lesson to be prepared out of class in algebra consists usually of problems taken from the text-book. In geometry the lesson commonly calls for a studying of theorems to be recited in class. Other types of lessons reported are: study of definitions, rules, methods of solution, and general principles; writing of notes, outlines, and summaries, demonstration of original theorems, solution of numerical problems based on geometrical relationships, problems in geometrical construction, practical problems, invention of problems to illustrate a principle, plotting of graphs, construction of models, outdoor measurements.

SPECIAL METHODS AND DEVICES.

The following specific methods and devices were listed in the principal questionnaire and reporting officers were asked to cross out those not in use, to indicate the time during which each method had been used, and to state whether it were still in use. The number after each item indicates the percentage of replies in which the method was reported to be in use.

[12]Based on returns from the supplementary questionnaire.

Use of squared paper 49
Preliminary course in observational geometry preceding formal demonstration 32
Laboratory method 27
Use of historical material 26
Heuristic method 24
Development of course in geometry without a text-book 20
Paper folding 19
Study of logic in connection with geometry 16
Mathematical recreations 10
Organization of a mathematics club among the pupils 4

In nearly all cases methods once used were reported to be still in use, but a few schools after a trial have abandoned the teaching of geometry without a text-book, and the use of a preliminary course in observational geometry.

Perhaps the most noteworthy feature of this record is the general use of squared paper, which has been introduced within five or six years by most of the schools which stated the period of use.

SOURCE AND VARIETY OF PROBLEMS.

The most common practice is to use the problems in the pupil's text-book or to supplement these by dictated problems, but in many schools the pupils have at hand more than one collection of exercises. Historical problems, and those drawn from other school subjects and from current events, are said to be used in about half of the schools replying. Problems based on industrial appliances and processes and those involving out-of-door measurements are used in many of the boys' schools and co-educational schools.

EQUIPMENT.

Three-fourths of the returns to the principal questionnaire indicate, on lists of apparatus and tools, which of the articles are possessed by the school.

About forty per cent of the schools replying reported mathematical reference libraries varying in size from two or three volumes to several hundred volumes. The median size is fifty volumes.

Three-fourths of the schools have geometrical models and drawing tools for use with the blackboard. A measuring tape is part of the general equipment of half of the girls' schools and two-

thirds of the others. About one-third of the girls' schools and more than half of the other schools include a plumb line in their lists of mathematical apparatus. One-third of the schools for boys and for both sexes, and a small proportion of the girls' schools have engineers' transits and nearly as many have sextants. A few schools report other surveying instruments which were not included in the printed list. About one-fourth of the schools have slide rules, coördinate blackboards, and spherical blackboards; a smaller proportion have portraits of mathematicians and a very few have lantern slides illustrating mathematical subjects. On the whole the boys' schools have more extensive general equipment than the others.

In practically all of the schools each pupil is supplied with a ruler and compasses. In a majority of the schools he has also triangles, protractor, dividers, and squared paper; and in many schools a ruling pen is added to the pupil's individual equipment.

With the exception of the possession of a mathematical library which was indicated by recording the number of volumes, an item of equipment not crossed out stands as a possession of the school. This fact doubtless makes the foregoing proportions too high.

TIME OF EMPHASIS UPON LOGICAL RELATIONS.

In accordance with the suggestion of the Central Committee in its report outlining the plan of the investigation, a question was included in the principal questionnaire asking at what stage (grade) emphasis is shifted from manipulative skill to the understanding of logical relations. Only about forty per cent of the returns gave answers to this question, the replies from the girls' schools being especially meager. The question seems to be too vague to make the reports of much value.

Every grade from the first year in the primary school to the beginning of the college course is mentioned as the time for emphasizing logical relations. Many lay stress on reasoning from the beginning of the course, and others say that the change of emphasis comes about "gradually," "at no definite time," or "varies with the class."

The grade mentioned most often as the point of transition in the reports of each class of schools (boys', girls', and coeducational) is the second year of the four-year high school course when pupils are about fifteen years of age. The general tendency seems to be to make the change of emphasis earliest in the girls' schools and latest in the boys' schools.

Examinations and Tests.[13]

EXAMINATIONS GIVEN BY THE SCHOOL.

Formal written examinations are given by nearly all the schools, varying in frequency from twice a month to once a year. There are two well-marked tendencies, one toward short monthly examinations, and the other and more general one toward longer examinations two or three times a year. Two examinations are commonly given in the girls' schools and three in the boys' schools and coeducational schools.

The examinations vary in length from thirty minutes to 240 minutes. In the girls' schools and coeducational schools, monthly examinations commonly last about forty-five minutes, and term or semiannual examinations two hours. In boys' schools there is greater variation in practice but the tendency is toward longer examinations, three hours being nearly as common as two hours for term examinations.

In a few schools promotion is dependent solely upon the passing of these examinations, but the common practice in calculating the pupils' standing is to give examinations one-half or one-third of the total weight. The papers are in almost all cases set and marked by the teacher.

In addition to the formal examinations written tests are given in most schools, sometimes weekly but more commonly once or twice a month. These tests occupy in most cases about forty-five minutes.

PURPOSE OF EXAMINATIONS GIVEN BY THE SCHOOL.

The purposes most generally recognized for examinations given as a part of the school work are to serve as a spur to pupils and as an incentive to review and organization of subject matter. The latter purpose is considered by many to be the most important. Most of the teachers consider examinations of some value as tests of a pupil's ability and progress, but in both these respects many point out that such tests are often misleading. There is nothing in the replies to indicate that examinations are used to measure a pupil's progress with any degree of exactness. A majority of the teachers consider that examinations act as a spur to teachers and serve as a test, for their own benefit, of the efficiency of their work. Many, however, do not think highly of this purpose of examinations. About half the replies approve of examinations for the purpose of comparing the rela-

[13]Data of supplementary questionnaire.

tive standing of different classes. The purpose securing the least support is that of testing the efficiency of the teacher for the enlightenment of school officers.

ILL EFFECTS OF EXAMINATIONS GIVEN BY THE SCHOOL.

In answer to the question, "What ill effects have you noticed of the examinations given in the school by teachers or school officers?" forty-one schools replied, "None," and thirty gave no answer, which in most instances is probably equivalent to the answer, "None." The ill effects most frequently mentioned are nervous excitement (twenty-eight cases), "cramming" (fifteen cases), tendency to place a wrong interpretation upon the value of examinations, including working for marks (fourteen cases), discouragement of weak students (ten cases), and temptation to dishonesty (nine cases). Most of the reports referring to nervous strain came from girls' schools; only two were from boys' schools. In many instances the teachers reporting emphasize the fact that the ill effects are confined to a few individuals.

Modifications of school examinations are suggested in only a few of the replies. These include exemption from examinations for pupils of high standing, increase in number and decrease in length of examinations.

ADMISSION OF STUDENTS TO HIGHER INSTITUTIONS.

Two methods are in common use for determining a student's fitness to enter college. Namely (1) examinations by the college or by the College Entrance Examination Board, and (2) a certificate furnished by the school of the completion by the student of the requirements prescribed by the college. Among the 113 schools reporting on this matter, practice seems to be about equally divided between the two methods. In twenty-two schools all candidates take examinations, in seventeen all enter on certificate, while in the others, the two methods are combined in all proportions. In New England the examination method is the common one, and in the North Central States the certificate. In the Middle Atlantic States a majority of the schools send more than half their students to college "by examination" but many use the certificate freely. Among the girls' schools there appear to be two distinct groups. In the larger group the certificate is used freely, in the smaller one it is never used.

The variation in use of the different methods is due in part to the demands of the colleges, since a few of the largest institutions admit students only by examination. It is evident, how-

ever, that many schools are not in favor of the certificate plan, and prefer to have their students take examinations.

EFFECT OF COLLEGE ENTRANCE EXAMINATIONS.

A large majority of the schools report that the course of study has been affected by college entrance examinations. The most general criticism is that the courses are overcrowded.

Only a few mention any effect on methods of teaching, but nearly all of these agree that much time is devoted to drill in preparation for the examinations which would otherwise be omitted. The papers of previous years are used for practice. One school requires its students to spend alternate Saturday mornings after New Year in taking these practice examinations. A few say that the restrictions imposed upon the freedom of the teacher by the necessity of preparing for the examinations tends to make his work mechanical.

Most of those who refer to standards of work think that they are raised by the examinations. A few think that they are lowered. Others say that they furnish a definite standard.

EFFECT OF THE CERTIFICATE PLAN.

A majority of the schools which send pupils to college "on certificate" report that no changes have been made in course of study, methods of teaching, or standards of work as a result of inspection of the school or scrutiny of the records of its graduates by college officers. Several, however, say that the work has been made more thorough in response to these checks. Some schools keep a record of the college work of their graduates who have been entered "on certificate," and several make a practice of certifying only pupils which attain a high standard.

One teacher says that the success in college work of the certified graduates of his school encouraged him to depart further from conventional methods and courses. Another says that the responsibility of a school for the college work of a graduate whom it has certified stimulates teachers to strive to give their pupils a real grasp of the subject rather than a temporary knowledge such as serves for passing an examination.

Mathematics and Coeducation.

As the practice in the Private Secondary Schools of the United States is about equally divided between coeducation and separate education of the sexes, this field seems to offer a peculiarly favorable opportunity for studying the relation of coeducation

to mathematical education. The practice in the different types of schools has, therefore, been presented in the foregoing discussion in relation to most of the points considered.

To supplement the statistics bearing upon actual practice, it was felt that the opinions of the teachers as to the bearing of coeducation upon the effectiveness of mathematics teaching would be of value. Accordingly, the supplementary questionnaire for coeducational schools contained questions calling for such opinions. Thirty-six replies were received.

Nine of the teachers answering the questions had taught in coeducational schools for not more than 5 years; 13 from 6 to 10 years; and 13 over 10 years. Only six had taught separate classes of boys; and only three, separate classes of girls, all of whom were included among the six who had taught boys alone. The fact that so few of the replies came from teachers who have had experience in teaching the sexes separately evidently diminishes the value of the testimony.

In all the schools represented by the replies, coeducation had been in use from the establishment of the school, but one reported having separated the sexes for class instruction during recent years. Two schools besides the one just mentioned reported that there is some prospect of separation of the sexes in class work, in the interests of a better adaptation of rate of work, character of subject matter, and methods, to peculiar characteristics of the sexes. None of the other teachers see any prospect of the modification of the present plan.

Teachers were asked to compare the sexes with regard to their success in passing the requirements in the various mathematical subjects. In arithmetic, 20 report no difference; 7 state that boys are more successful; 4 that girls are more successful; in algebra, 21 find no difference; 6 consider boys more successful; 5, girls more successful; in geometry, 13 report that the sexes have equal success, and 19 consider that boys excel; in trigonometry, 9 report no difference and 14 consider that boys are more successful. Several said that, while boys are as a rule superior as mathematical students to girls, there are frequently brilliant students in mathematics among the girls.

In regard to the relative tendency of boys and girls to choose elective courses in mathematics, the answers indicate that boys are much more inclined to elect such courses than girls are.

In accuracy of intuition in regard to mathematical relations,

6 of the teachers report no difference in the sexes, one considers girls slightly superior, and 19, boys superior.

In skill in formal processes, 11 find no difference, 8 find boys superior, 10, girls superior.

In grasp of logical sequence, 6 report no difference, and 25, boys superior.

In ability to solve "original theorems," 28 say that boys are superior, and 3 report no difference.

In answer to the question, "Do you think that the subject matter of high school courses in mathematics should be the same for both sexes?" 14 replied, "Yes;" 9 replied, "No;" and 7 replied, "Yes," with qualifications. The differences in subject matter for boys and girls regarded as desirable by some teachers are: (1) Requirements in algebra and geometry should be less for girls than for boys. (2) Solid geometry and trigonometry should be omitted or made optional for girls. (3) The applications should be such as appeal to the interests of both sexes.

Only one difference in methods of teaching the sexes was suggested, and that was mentioned by only one teacher, namely, that mathematics be developed empirically rather than logically in the instruction of girls. It is interesting to note in this connection that one teacher, arguing from the same characteristics as shown by the sexes, would give the girls special training in logical reasoning.

To sum up, most of the teachers who gave testimony agree that there is a difference in the mental traits of boys and girls and in their ability to do different kinds of mathematical work; but a decided majority do not consider that these differences are sufficiently great to warrant separate class instruction. About a fourth of these teachers would provide for sex differences by a slightly different treatment of pupils in the same class and by making part of the work elective; another fourth feel that the differences are too great to permit the most effective work unless separate classes are provided.

Aim of Instruction in Mathematics.

With a view to gaining some insight into the attitude of teachers of mathematics toward their work and to learning the extent to which they attempt to analyze their problem, the supplementary questionnaire included a list of questions on the aims of instruction in mathematics and the means employed to attain these aims. The list included questions on the general aim of

mathematics teaching, the aims especially served by the different mathematical subjects, the inclusion of individual topics in the curriculum for specific purposes, the relation of course of study in mathematics to vocational training, and the value of mathematics for mental discipline.

AIM OF INSTRUCTION IN MATHEMATICS IN GENERAL.

In presenting the question on the general aim, nine statements were given of which teachers were asked to cross out those not recognized, a method which gives no means of discriminating between controlling aims and those having only a slight influence. This defect is remedied to some extent by the questions on the relation of particular subjects and topics to the various aims.

Of the 136 replies, all recognize *mental discipline* as one of the aims of mathematics teaching, and all but three work for the *development of an accurate conception of space and form.* Nearly all approve of *preparation for more advanced work in mathematics, preparation for studying other subjects, the teaching of mathematical truths for their own sake, and the cultivation of an appreciation of the importance of mathematical knowledge in modern life.* Only eleven schools are able to ignore *preparation* either *for examination* or *for requirements imposed by outside authorities*

The *preparation for vocations* is the aim least generally recognized. Ninety per cent of the boys' schools recognize this aim, but only a little more than half of the girls' schools regard it.

PREDOMINANT AIMS IN TEACHING SPECIAL SUBJECTS.

About one-fifth of those reporting apparently find it difficult to select the aims chiefly served by the different mathematical subjects, for they pass the question by. The replies represent a very wide variation of opinion, every one of the aims being mentioned by several as important in connection with each of the subjects. Very few consider any one aim as sufficiently influential in teaching any subject to warrant its standing alone as *the* predominant aim.

A rather marked difference exists in point of view of the teachers in girls' schools on the one hand and those in boys' schools and coeducational schools on the other. Among the girls' schools, mental discipline is most generally regarded as a predominant aim. In the other schools, vocational training and preparation for advanced work in mathematics are mentioned most frequently in connection with arithmetic and trigonometry

and preparation for study of advanced mathematics and other subjects in connection with algebra. In geometry, mental discipline takes first place and the development of accurate conceptions of space and form stands second in the reports from all three types of schools.

TOPICS INCLUDED IN THE COURSE TO SERVE SPECIFIC AIMS.

About thirty per cent of the reports make no attempt to answer the question on the relation of aims to particular topics of the course. The others represent the greatest variety of opinion. Many teachers apparently have no specific purpose in mind in teaching any topic, and there is little agreement as to the topics which best serve a given purpose. Every one of the nine aims listed in the paragraph on aims in general is given by several teachers as the chief purpose for including *graphs* in the course. One can hardly avoid the conviction that custom as expressed in college entrance requirements and in text-books is the chief factor in determining what topics shall be taught.

PROPOSED REQUIREMENTS IN MATHEMATICS FOR VARIOUS CLASSES OF STUDENTS.

In the opinion of the majority of teachers there is need of very little differentiation of mathematical courses in accordance with vocational intentions or plans for higher education. Arithmetic, algebra, and plane geometry would be required for all classes of students, except the boys preparing for technical schools, who in the opinion of the majority have had enough arithmetic in the elementary schools. They should, however, have solid geometry and trigonometry in addition to the other subjects. While this represents the consensus of opinion, several modifications are strongly supported. For college preparatory students of both sexes and for boys preparing for law and medical schools, nearly half the teachers would omit arithmetic as a requirement in the secondary school. More than a fourth of the replies call for solid geometry as a requirement for boys preparing for college, and advanced algebra for boys intending to enter technical schools. For boys anticipating a business career and for girls whether preparing for technical schools, for commercial positions, or for domestic responsibilities a strong minority would require neither algebra nor geometry. In the case of the girls this view is supported by from twenty per cent to forty per cent of the replies. A few would make the

geometry concrete for girls not preparing for college and many would treat the subjects differently for commercial students (especially girls). The modifications suggested relate chiefly to shortening the courses, omission of theoretical discussions, and emphasis upon practical applications.

Analytic geometry and elementary treatment of the calculus are proposed by only four or five teachers as part of a course for boys preparing for technical schools.

The following table gives, for each class of students, the number of replies recommending the subject listed in the first column:

Proposed Requirements	Boys for College	Boys for Tech. S.	Boys for Business	Boys for Prof. S.	Girls for College	Girls for Tech. S.	Girls for Commer.	Girls for Home
Arithmetic	40	30	63	42	52	69	82	77
El. Algebra	80	80	69	73	98	64	65	74
Advanced Algebra	6	24	2	3	5	3	1	1
Concrete Geo.						9	5	7
Plane Geom.	80	80	61	71	98	59	53	65
Solid Geom.	21	67	9	15	10	3	2	2
Plane Trig.	11	60	6	12	8	2		1
Analyt. Geom.		4						
Elements of Calculus		5						
Total No. of Replies	80	80	77	75	98	85	88	92

MENTAL DISCIPLINE.

It has already been said that all the teachers reporting recognize mental discipline as one of the aims of mathematics teaching. As psychologists are claiming that too much reliance has been placed upon the supposed value of study of a single subject for general improvement of mental processes, the opinions of teachers of mathematics upon this point seem pertinent to a discussion of aims.

To the request, "If you regard mental discipline as an important aim, explain as fully as possible what you mean by mental discipline," nearly nine tenths of the teachers give some reply, but very few attempt to analyze their conceptions. Mental discipline is, in most cases, described in vague, general terms, loosely applied, representing all sorts of mental and even moral qualities which are believed to result from a discipline of the mind. Nearly all have a firm conviction that general abilities are gained through exercise of the mind upon a particular subject, especially mathematics.

A composite of the replies shows that mental discipline is considered to be that which produces an improvement in intuition, judgment, memory, imagination, intelligence, reason, mental powers, reasoning powers; or an improvement in ability or power of mental concentration, initiative, sustained effort, analysis, generalization; or an improvement in ability to think rapidly, clearly, independently, logically, to recognize the essential elements in a problem, to note resemblances and relationships, to groups and apply principles, to understand cause and effect. One of the most generally approved results of mental discipline is the ability to express thoughts clearly, concisely, and accurately. In a few cases mental discipline is described as the formation of habits; habits of mental concentration, of industry, of accuracy in thought and expression.

Following are a few examples of more definite analyses of the authors' conceptions of mental discipline:

"Mental discipline is that process of mind which (1) recognizes there is a problem. (2) Wills that the problem be solved. (3) Perseveres until the desired goal is obtained."

Results of mental discipline are "ability to observe well, to make correct records, written or in memory, of things observed, to sift data or evidence, to draw correct inferences, to state these inferences in clear language."

In only a few cases, such as the following, is the influence of modern views of formal discipline apparent.

"The modern psychologists have made this a difficult thing to do, (explain meaning of mental discipline), but the habits of making exact statements, of finishing a piece of work in hand, of seeking the proof for each statement, not only ought to be valuable but I am convinced are valuable."

"Mental discipline through mathematics for mathematical work consists in the acquirement of mathematical facts and ideas, processes, methods of solution and standards of accomplishment. Mental discipline through mathematics for other kinds of work consists, I think, in development or strengthening certain ideals or standards, such as logical perfection, mastery of difficulties, etc. General power is not necessarily gained by the study of mathematics, but the student *may* be so impressed by the logical perfection of mathematical reasoning as to test consciously his thinking on other subjects by similar standards, and the sense of mastery experienced in mathematical victories may give confidence in attacking other difficulties."

About half of the teachers consider mathematics superior for mental discipline to all other subjects. A considerable number consider it superior for certain kinds of discipline, usually for improvement in logical reasoning or in accuracy. A few qualify their approval, saying that mathematics is superior to some subjects or for some minds. About ten per cent of the teachers do not regard it as superior to other subjects and one says, in answer to the question, "Decidedly no."

The nature of the superiority is usually stated in terms of the desirable qualities of mind which are said to be produced more readily through mathematics than through other subjects. One says it "requires thought." The superior qualities of mathematics most frequently referred to are its definiteness and the absolute trustworthiness of its principles. The simplicity of its data and the ease of checking results make this the best medium for training the student in logical reasoning. On the other hand, it is said to call for greater mental effort, and therefore to result in greater mental power.

Conclusion.

The preliminary classification of schools has been used comparatively little in describing courses of study and methods. Although location, religious connection, and various features of organization were considered in making tabulations, few distinctions between these various types of schools appeared in the data bearing upon the teaching of mathematics. The classification, while unnecessary for describing differentiation in courses and methods, has been retained because of its value in a description of the general characteristics of the schools included in the report.

The data reported by the schools has been presented as accurately as possible with almost no comment. It is not a complete description of mathematics teaching in private secondary schools, and we have indicated roughly limitations to the reliability of the figures, but in this form the report should be of more value for comparison of the schools of this field with the others than if interpretation reflecting the personal convictions of the members of the committee had been given.

In the discussion of *aims*, however, criticism of the prevailing views with regard to certain questions is perhaps implied, and in closing the report, a word of commentary may be permitted. The statement in regard to coeducation, and to the various questions

of aim show that few teachers are in the habit of analyzing their problem carefully. One of the greatest needs of mathematical education in secondary schools to-day is the scientific determination of its legitimate purposes. Teachers should be less content to be guided by an examination requirement or to have blind faith in the supreme value of their subject. There should be a conscious purpose in all teaching and a frequent attempt to measure results.

For the Committee,

October 1, 1910. WILLIAM E. STARK, *Chairman*.

WORLD COINAGE PLANNED.

Prof. Wilhelm Ostwald of Leipzig University, one of Germany's most distinguished savants, who lectured at Columbia and Harvard Universities in 1905, has originated a novel project for a universal world coinage.

He has been invited by the Merchants and Manufacturers' Association of Berlin to make the first public exposition of his idea before that organization. The association will ask leading bankers and exporters to attend the meeting and join in the discussion as to the practicability of Professor Ostwald's proposals.

The scientist's general idea is that the commerce and intercommunication of nations would be immensely facilitated and simplified by the adoption of a money system and coinage common to the whole civilized world.

"TOLERANCE" IN COINS.

The mint allows a certain degree of "tolerance" in coins. For example, the gold double eagle's standard weight is 516 grains, and the "tolerance" allowed is half a grain. A coin of this denomination may weigh as little as 515½ grains or as much as 516½ grains, but never less than the first nor more than the second figure. The standard weight of the silver half dollar is 192.9 grains, and the tolerance allowed is 1.5 grains. This coin may weigh as little as 191.4 grains and as much as 194.4 grains, but never more than the second figure. The standard fineness of all gold and silver coins is 900. In the gold coins a deviation of only one thousandth from this is allowed and in the silver coins only three thousandths. The so called five cent nickel coin is really only twenty-five per cent nickel, the rest being copper. One cent pieces are ninety-five per cent copper and five per cent tin and zinc.—*Philadelphia Record.*

A HOMEMADE PLANIMETER FOR CLASS ROOM USE.

By Ernest W. Ponzer,
Stanford University, California.

In the application of the integral calculus to actual problems arising in the field of applied science, especially in engineering practice, the evaluation of the definite integral is of fundamental importance. That the formulation of the definite integral, with its limits, from conditions existing where the calculus may be applied is one of the most difficult problems in the application of the calculus is quite generally recognized, especially by those instructors in the calculus who lead their students into the realm of the practical. The integrations involved, as such, do not begin to compare in difficulty with the formulation of the integral and its limits, and these in actual practice will be found to fall under a few heads, readily recognized and as readily executed. The difficulty generally lies in the fact that the student either does not have a clear notion of existing conditions which call for the use of a definite integral, or that he is not exactly certain as to what the calculus will do for him in the solution of his problem.

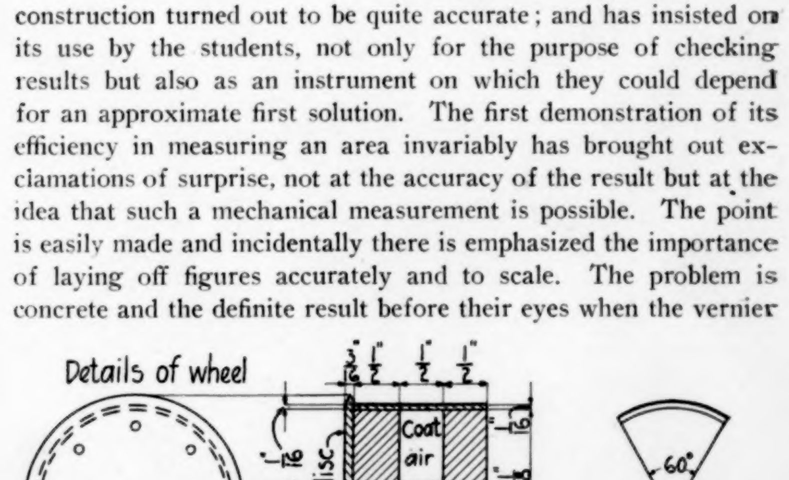
In order that the student may have the courage of his convictions and really believe that the calculus will help him it is essential that he have clearly in mind the notion that in its fundamental form the value of the definite integral may be represented by an area drawn to scale. This correspondence on the face of it may seem quite apparent from the general proofs given in most texts on the integral calculus—or in spite of these proofs; the fact remains that, in order to have the average student in the calculus appreciate the full significance of this correspondence, it is necessary to do much concrete and definite work in its application.

Several methods easily suggest themselves which, undoubtedly, ought to be incorporated early in a course on the integral calculus. Among the first of these methods to suggest itself is the practice quite common among engineers—why not in the class room?—of plotting accurately and to scale $f(x)$ between $x = a$ and $x = b$ when the integral $\int_a^b f(x)dx$ is desired, and then actually counting the units of area representing approximately the value of the definite integral so formulated. This gives only an approximate result? Suppose it does only that. The engineer using such a scheme generally has a fair estimate of what his result should be, and a definite notion of the limit of allowable error.

And very often he cannot get an algebraic expression for $f(x)$ for the simple reason that no one can. An approximation is obtained which answers the purpose well, and which is sufficient for the problem in hand. The method is excellent and should be included in the fundamental principles of the teaching of the integral calculus.

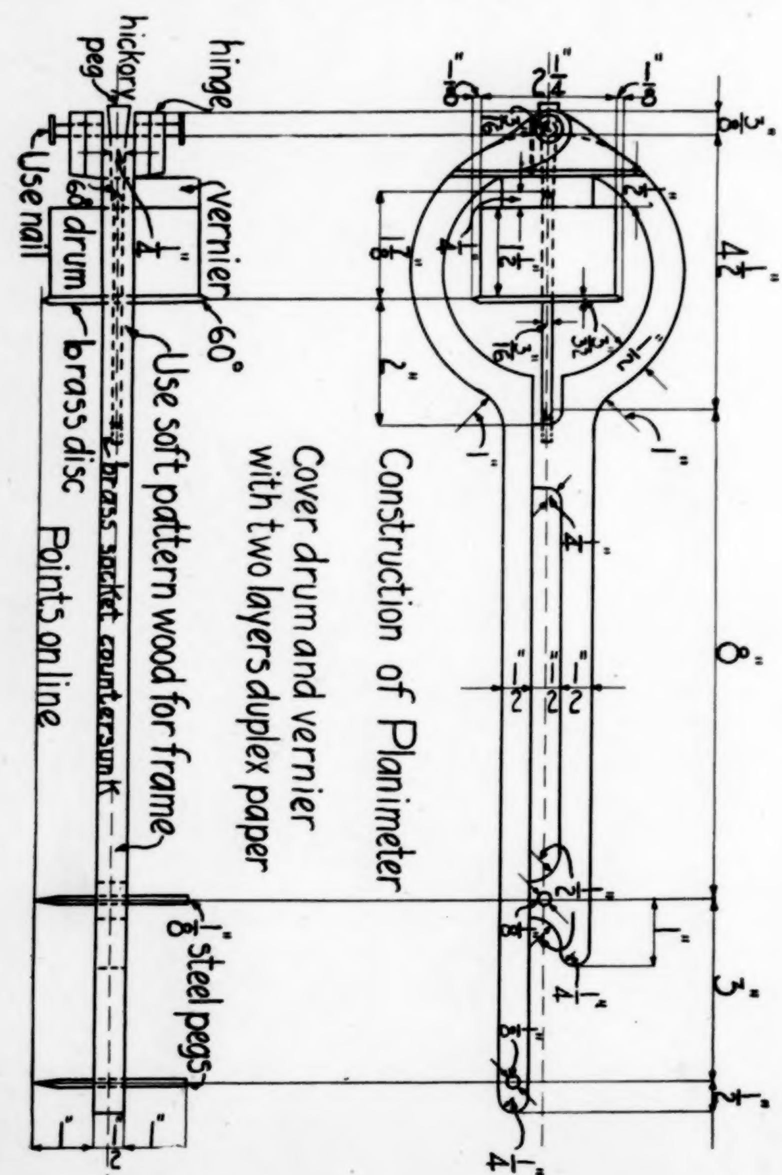
A second method easily suggesting itself is found in the use of the formulas for approximate integration generally included in an appendix, if given at all. There is no valid reason why the Trapezoidal, Simpson's, or Durand's Rules for approximate integration should not be used at this stage, partly for their own sake in problems where real approximations only exist, and partly for the sake of checking up on the more accurate value of $\int_a^b f(x)dx$ whenever the latter can be evaluated. A judicious use of these formulas for such checking processes, and to emphasize the fundamental notion of the area correspondence is well worth while.

However, of all efficient methods for the emphasis of this notion of the correspondence of definite integral and area, the use of the planimeter in the class room—and by the students themselves—is the most effective. The writer has had in use in his class room for several years a homemade planimeter, which in its construction turned out to be quite accurate; and has insisted on its use by the students, not only for the purpose of checking results but also as an instrument on which they could depend for an approximate first solution. The first demonstration of its efficiency in measuring an area invariably has brought out exclamations of surprise, not at the accuracy of the result but at the idea that such a mechanical measurement is possible. The point is easily made and incidentally there is emphasized the importance of laying off figures accurately and to scale. The problem is concrete and the definite result before their eyes when the vernier



is read. This method of checking results is recommended as thoroughly efficient and should find a place in the teaching of the integral calculus.

The details of the construction of the planimeter used in my class room are given in the accompanying figures. Sufficient ex-



planation is given so that any student having a reasonable proficiency in the use of tools can construct one for himself, an exercise in manual training which might easily be recommended for its own sake. No strenuous endeavors were made to proportion the lengths of the arms; but when calibrated it was found that one revolution of the drum when the pointer on the tracing arm was moved around an area corresponded to about 90 square inches, a convenient size for use with coördinate paper in letter size sheets and on an ordinary drawing board. The drum was graduated by tracing in both directions the peripheries of accurately constructed cardboard rectangles containing 2, 4, 6,....50 square inches respectively. It was found that equal additional parts of a revolution of the drum measured equal additions to the area. These divisions were first marked with pencil on the drum of the rolling wheel and later inked when the calibration was completed.

The construction of the roller wheel is shown in the figure and the brass disc used has given excellent results, though perhaps a piece of soft steel would give better service. This roller part including the drum with disc attached and nail for axis should be turned to shape in a metal lathe, and care should be taken to have the whole roll true.

The vernier, on a 60° sector of wood coated with mailing tube and paper in a manner similar to the drum, should be laid off so that its ten divisions subtend the same arc as nine divisions on the drum.

When graduated the whole instrument should be cleaned carefully and several coats of clear shellac applied, after which a bit of floor wax and plenty of polishing will give the whole a finished appearance. There is no reason why the same instrument could not be used in the teaching of geometry whenever congruent, equivalent, proportional, or irregular areas are under consideration.

GRADES OF COAL.

All the coal mined in Georgia is high-grade bituminous and makes a good steam fuel. As bunker coal it has no superior in the South Atlantic states. It also makes excellent coke, and about 30 per cent of the output is made into coke which is sold to the furnaces at Chattanooga and other points in Tennessee and Georgia.

ARITHMETIC IN A MASSACHUSETTS INDUSTRIAL SCHOOL.[1]

By W. H. Dooley,
Principal of the Lawrence Industrial School.

Before beginning to explain how arithmetic is taught in one of the industrial schools of the state it might be well for me to explain the aim of the school, as the aim determines very largely the methods of instruction.

The Lawrence Industrial School provides for three distinct classes of students. First. That of offering to children who have reached the age limit of compulsory education in the grades, a further education which aims to prepare them to go into some form of industrial occupation, as the high schools prepare them for professional work. Second. To offer to young men between fourteen and twenty already employed, part time instruction in which the employer gives the time out of the working day. Third. To offer to adults already at work, an opportunity for further study which will aid them to become more efficient workers.

While the day school offers a three year course in the textile arts for boys, mechanic arts for boys, and the domestic arts for girls, it recognizes the fact that the majority of children cannot afford to give so much time to education beyond fourteen years of age. Hence, the arithmetic is planned with the other work, so that the work of each year is so far as it goes complete in itself; it is not taught on the theory that it will be of value at some later period in the course.

The class of children that have attended the day school may be divided into four grades. The first grade includes those who have attended the high school for two or three years, and whose parents do not feel that they can afford to give more time to the child for purely academic work, and yet feel that they can afford to send the child to school a year or more in order to aid him in getting started in some form of skilled industrial work. The second grade includes the children who do not like to study, who want to do things, who want to see and know the use of things, who are of a practical rather than an academic mind. Third grade, pupils who have graduated from the grammar school and desire to "learn a trade." Fourth grade, children fourteen years of age who are in the grammar school, and whose parents feel that the child has wasted his time in school, and are anxious that he should make better use of his time.

[1]Read before the Association of Mathematical Teachers in New England, April 16, 1910.

The arithmetic work in the day school consists of a thorough drill in practical problems in the metal and wood trades for those taking the mechanic-arts course and a drill in practical mill problems for those taking the textile course. Problems dealing with wages of different employes, services for hours, days, weeks, and so on, followed by the problems and calculations involved in each operation that takes place in the mill and shop. Each operation is explained in detail by means of models of gears, wheels, bolts, and so on, and by specimens of raw cotton, wool, yarn, and cloth. These problems involve the operations of addition, subtraction, multiplication, division, fractions, rule of three, alligation, percentage, square and cube root. So that a thorough drill in arithmetic is given. The propositions in geometry are assumed to be true, and practical problems involving their use are given. Algebra is introduced incidentally, to abbreviate rules, in connection with the work in arithmetic. Practice is given in setting up formulas from rules and interpreting a formula.

Each course has a separate text-book written by an instructor, and the problems are taken from the local industries. In this way a thorough foundation in arithmetic (including the use of square and cube root tables) is obtained the first year. Pupils who find it difficult to understand arithmetic in the grades have no difficulty in understanding it when it is presented in the concrete form. During the second and third year arithmetic is taught only as the problems are met in the actual shop and mill practice.

Objection may be made to this mechanical, rule-of-thumb method of teaching arithmetic. My answer to this is that the success of a nation depends upon the ease with which the industrial workers can adapt mathematics and science to industrial matters. In fact, the graduates of technical schools fall easily into the rule-of-thumb methods as soon as they become part of the industrial world.

I do not mean to say that we stifle the pupil's desire to know the reason why, but rather encourage questions about the work. I believe that the logic of mathematics should follow the practice rather than the practice the logic, for a great many, if not the majority, have not the mental equipment to get much training from the logic of mathematics. But I am sure that all can get the practice of mathematics, particularly when they see an incentive for its study.

Instruction in arithmetic for adults who are working at the trades cannot be taught as systematically as it is taught to chil-

dren in the day school. The former attend school to satisfy a definite need and have intensely practical aims, and are unwilling to study systematically the entire subject of arithmetic; even when they know they are deficient in the fundamentals they demand that the instruction shall deal with the specific problem which they have in hand.

This has been done by classifying our evening pupils according to their trades. For example, there is a class in arithmetic for engineers and a class in the same subject for boiler firemen. They are taught arithmetic by taking problems that occur in their daily work and solving them. These problems involve addition, subtraction, multiplication, division, fractions, percentage, and the use of a formula. In working out the problems the instructor at the same time teaches the operation of multiplication, and so on. A formula is briefly explained as an abbreviated rule to assist one to see at a glance the required operations embodied in the rule.

The machinists have a separate class. The textile designers have a class in arithmetic called cloth calculations. In this way the instruction in various branches of mathematics is adapted to meet the needs of the mill operative, the machinist, and the steam engineer. The terms used in the class room savor of the shop and mill. For example, the problem of finding the heating capacity of a boiler does not appeal to the weaver in the mill. On the other hand, how to find the size of a pulley for a certain loom does not awaken the interest of the steam engineer as much as the problem involving the same operations dealing with a problem in the engine room. Special text-books along this line of work have been edited by the school and published by the state.

Statistics show that eighty per cent of girls will eventually marry and become housekeepers. The problem is to give them preparation for that life and to prepare them for the work they must do to earn their living between the time they leave school and are married. In the girls' department arithmetic is taught by means of problems dealing with the ordinary affairs of life, that is to say, problems that a girl or woman would meet in the trade in which she is engaged, and in the home.

The subjects of the problems are chosen within the limits of reality. Every woman, no matter what station of life she holds, has more or less business transactions. She has been taught interest in the grammar school and can find the amount of $999 for nine years, nine months, nine days at nine and a half per cent,

but how many girls can tell you what $500 deposited in the Lawrence Savings Bank, January 1, 1905, would amount to to-day? The girls are taught how to read gas meters, and to figure how much is due the gas company, if the bill is paid early enough to get the discount.

Grammar school arithmetic teaches how to find the amount of a note, but does not give the penalty or inform pupils of the responsibility attached to signing a note.

Problems in the cost of living are firmly impressed. For example, how will a woman divide her income to dress decently even when that income seems too small to divide?

REPRESENTATIVE PROBLEMS.

1. I put $500 in the Lawrence Savings Bank, January 1, 1905. I have drawn nothing out. How much have I in the bank?

2. A man buys property worth $3,000. Takes out a $2,000 mortgage. What will the interest on the mortgage be? If he does not pay the interest how long can he hold the property?

3. Many are asking for lemonade at the lunch counter. What must we charge to cover the cost? (Little or no data given.)

4. How much Hamburg do you need for the ruffle on your petticoat? What will it cost?

5. How much long cloth will you require to make a 10-inch flounce on your skirt?

6. Make a list of articles for wearing apparel you will need for a year. Keep the cost within $50.00.

7. Which is the better off financially; a girl earning $4.00 a week as a housemaid or earning $7.00 a week as a salesgirl?

A considerable number of arithmetical problems set for girls deal with household things, domestic economy, and the results of thrift. When this industrial arithmetic for girls is well taught, it helps to introduce into the homes that methodical spirit which regulates expenses by receipts, inspires foresight, and makes the produce of thrift fruitful.

OIL LANDS WITHDRAWN.

A withdrawal of 5,760 acres of supposed oil land in California was made on the recommendation of a chief of field division of the General Land Office, making the total outstanding oil withdrawals 4,660,650 acres.

COAL IN UTAH.

The areas in Utah known to contain workable beds of coal are estimated by M. R. Campbell, of the United States Geological Survey, to aggregate 13,130 square miles, and there are 2,000 square miles of which little is known but which may contain workable beds of coal. The original contents of these fields are estimated by Mr. Campbell to have been 196,458,000,000 short tons of coal.

ESTIMATION OF WEIGHTS AND DISTANCES FOR PHYSICS STUDENTS.

By Wm. G. Fuller,
State Normal School, New Paltz, N. Y.

The inability of the average high school pupil to estimate with any degree of accuracy simple weights and distances is a lamentable fact, and yet all must admit that the condition does exist. So often in the daily life of the students, cases arise in which it is of the utmost importance that a distance or weight be correctly estimated, and yet how few of them have a clear conception of even our common standards of measurement. This condition is undoubtedly due to the fact that the pupils have never given attention to the matter, and the improvement that will be noticed after a small amount of drill justifies this conclusion. The following methods of introducing the subject have been found to work successfully with a number of classes.

During a class discussion as to the distance between two buildings on the school grounds, it developed that a number in the class did not have a clear conception of just how far a hundred feet would reach, and so after school, stakes were placed along a straight piece of road, one hundred, three hundred, and five hundred feet apart, with the proper distance marked on each. A clear idea of the standard distances being thus obtained, the estimates on unknown distances were much improved. If the teacher requests the pupils to pass judgment as to the height of some of the more prominent landmarks of the town, standards of altitude may thus be established.

Much valuable training may be given in the class room in the estimation of short distances, by questions such as the height of the room, the length of the lecture table, etc. After the estimates are all in, actual measurement may then be made, and this not only makes the interest in the matter keener, but enables the pupils to observe the error, and consequently make a closer estimate on the next trial. From tests made in the class room on estimating the distance between two lines on the blackboard, it has been found that some students can average, on distances up to a yard, within half an inch of the correct result. An excellent way of impressing on the students the relation of the inch and centimeter, as well as the actual value of each, is to allow the class to estimate the distance between two lines on the board, first in inches, then in centimeters, and determine the ratio of the two.

The experiment involving the measurement of a straight line is a valuable one for training in accuracy, but if the student turns in an answer of five and one-half feet when so many inches was correct, much of the benefit to be derived from the experiment is lost. Students should be taught first of all to be reasonable, as this is the essential foundation for training in accuracy.

The estimation of weights may well be taken up in connection with the study of density. In this, guesswork may be largely eliminated, and a little mental figuring on the part of the pupil, will produce some remarkably close results. It takes but a short time to impress on the pupil the fact that the weight of objects depends not only upon the volume, but upon the density of the material as well. Regular blocks of wood are excellent to begin with, and later small spheres of the different metals afford good material. In no other way can the principles of density and specific gravity be so well presented.

Estimation of the weights of the different members of the class affords valuable training, and never fails to arouse a considerable degree of interest. Perhaps the only objection that can be made to this is that the actual determination of heavy weights in the average laboratory is usually a troublesome, if not impossible task, due to the lack of suitable scales, and consequently the results cannot be verified. However, the following device, which has been given a thorough trial, not only obviates this difficulty, by giving a fairly accurate method for the determination of large weights, but also furnishes one of the best methods of presenting the principle of moments.

A stout plank about ten feet long is balanced over a sharp-edged fulcrum, (a block of hard wood is suitable for this) and a boy whose weight is known is placed near one end of the plank. The moments on the other side of the plank may now be computed, and the weights necessary to balance the boy may be marked directly on the plank. Weights likely to correspond to the weights of the students should be chosen, say from 100 to 160 pounds.

If now the student whose weight is to be found gets on the plank near the fulcrum, and moves slowly backward until the weight of the boy on the other side is counterbalanced, the results may be read off directly.

Many variations are possible in the manipulation of this apparatus, and its extreme simplicity, as well as the accuracy of the results that may be attained by its use, should make it an essential feature in the equipment of every laboratory.

THE HUMIDITY OF THE AIR IN SCHOOLROOMS.

By Robert M. Brown,
State Normal School, Worcester, Massachusetts.

The problem of proper humidity in rooms generally and especially in schoolrooms has not had wide consideration. We live largely in an artificial climate; the winter cold is too severe so we have heated dwellings; we protect ourselves from inclement winds; we put roofs over our heads to shut off the rays of the summer sun and shelter us from the rain; we regulate the temperature in our schoolrooms as far as we can so as to give the best condition possible for work; by shades we cut off excessive heat and light; by a ventilating plant the freshness of the air is maintained, but we have neglected one important item, the humidity of the air. We know that we cannot tell temperature accurately by our bodies—a moist day, other things being equal, in winter will seem colder than a dry day of the same temperature. We say the day is raw and penetrating. Moist air is a better conductor of heat than dry air and the heat of the body is lost rapidly during the damp days of winter. On the other hand during a warm dry day we feel cooler than during a damp day under the same conditions. In this case the dry air absorbs moisture from the body and the sensation of coolness results, similar in kind but less in degree to that which is experienced in fanning. On the other hand when the air is moist on a warm day evaporation from the body is lessened and a feeling of oppression results.

It is known that one cubic foot of air at thirty-two degrees will hold when it is saturated 2.113 grains of moisture. Warm air can hold more moisture than cool air; and one cubic foot of air at 68 degrees will hold 7.480 grains. If air has in it less than fifty per cent of the amount of moisture it can contain the air is said to be dry; more than eighty per cent, wet. Air containing from fifty to eighty per cent of its possible content of moisture causes in the long run less adaptation and is, therefore, in the best condition for a schoolroom. Suppose air of thirty-two degrees, saturated and thereby containing 2.113 grains of moisture per cubic foot, is heated to sixty-eight degrees by a furnace with no addition of moisture from passing over water pans, and is forced into a schoolroom, the air will have 2.113/7.480 of its possible content of moisture or about twenty-eight per cent, which is very dry; but it is exactly what our furnaces are doing and the result is that in many of our schoolrooms the air is too dry

for the best health of the pupils. In this calculation, I have taken air at thirty-two degrees, saturated, while more frequently, we have winter days at thirty-two degrees and even with a much lower temperature when the air out of doors is relatively dry. The relative humidity of the air within the schoolroom depends on the humidity of the air without. Again, air at thirty-two degrees with a relative humidity of seventy contains more moisture than air at zero degrees with the same relative humidity so that the temperature of the outside air is a factor also.

In a series of experiments to find the humidity of the air in the study hall of the Normal School during October and November, a rather startling state of affairs was discovered which has since been remedied. The average humidity of the hall during the first eight school days of November was thirty-seven per cent, ranging from fifty-six per cent on November second to twenty-eight per cent on November eighth. Thirty-six readings during October yielded an average of forty-four per cent. During many days of this month there was no fire in the furnace and the windows of the school hall were open. The lowest reading for October was twenty-six per cent, on the thirteenth. A high barometric area was central over Massachusetts, the outside air was below the normal for the month and the building was heated. The highest reading was sixty-five per cent on the twentieth during a rainstorm. The instrument for measuring the humidity is the hygrometer, which consists of a wet bulb and dry bulb thermometer. The dry bulb is the ordinary thermometer; the bulb of the wet bulb is covered with a wick which extends into a reservoir of water so that the bulb is always moist. If the air is dry evaporation of the moisture from the wet bulb takes place and as in the process of evaporation heat is necessary, the heat is taken from the bulb and the wet bulb thermometer reads lower than the dry bulb thermometer. On the other hand if the air is saturated with moisture and can hold no more, the evaporation of moisture from the wet bulb ceases and the readings of the wet and dry bulb thermometers will be the same. In other words the greater the difference between the two the dryer is the air. The exact humidity is found by a table attached to the instrument. A variation of this instrument is the sling psychrometer.

Now when we consider that the dry region of Asia, the Trans-Caspian Desert, has a range of humidity from nineteen to forty-five per cent; in Africa, Tripoli has a humidity of thirty-three

per cent in August; and the Kufra Oasis, Sahara, twenty-seven per cent; Lahore, India, thirty-one per cent; and in our own country the dry Death Valley, California, has for five months a mean of twenty-three per cent, and Pueblo, Colorado, a mean annually of forty-six per cent, we realize that a schoolroom at thirty-seven per cent is no better than a desert. Such a condition does not conserve the best of our energy. Our bodies tend to adapt themselves to the conditions in which they are placed. The best temperature of a schoolroom is the one where the changes of adaption necessitated in the long run use up the least possible energy. So the best humidity of schoolrooms or homes is the one that approaches as near as possible to the normal for the locality. The normal relative humidity for Massachusetts does not range far from sixty to eighty per cent. It is not right to submit ourselves and our charges to the exceedingly dry air of the ordinary schoolroom if we believe that in matters pertaining to health we ought to be vigilant. The Sahara-like condition of many schoolrooms and living rooms ought not to exist.

The Normal School hall is heated largely by hot air which enters the room through two large flues at an elevation of eight feet from the floor. On November twelfth there was installed in one of the flues a steam pipe and a spray of steam has been injected into the flue and borne to the room with the hot air. For the eleven school days in November following the twelfth an average humidity of fifty-five per cent has been experienced. The range of humidity was from fifty to sixty-three per cent. Very dry air which absorbs the moistures from the body will not seem comfortable short of seventy to seventy-two degrees, but air with a humidity of from fifty to sixty per cent will be comfortable for study at sixty-seven degrees. A curious condition resulted recently when the hall, perhaps overmoist to the point of enervation, seemed comfortable at sixty-one degrees when a recitation room in which no moisture entered was reported cold at sixty-five degrees.

Similar experiments have been tried in other places and under other conditions. Professor Ward of Harvard reported[1] for a November month these figures; inside mean temperature, sixty-nine degrees, outside mean temperature, thirty-six degrees, inside mean relative humidity, thirty per cent; outside mean relative humidity, seventy-one per cent. Professor Ward states that

[1]The Relative Humidity of our Houses in Winter. Journal of Geography, Vol. 1, 310, 1902.

the relative humidity of a room depends on the temperature and humidity of the outside air, the amount of heat brought to the room by the furnace pipes, the amount of evaporation from pans of water either attached to the furnace or exposed in the room, and the extent air is admitted from windows.

In an office heated by steam in the University of Nebraska, a mean relative humidity of 18.6 was reported[2] for December, 21.0 for January, and 15.3 for February, while the outside mean temperatures were respectively 22.6, 26.8, and 19.2 degrees. As this condition was reported near the botanical laboratory, the writer infers that the effects upon the plants used for experimental purposes must be most trying and in many cases the experiments must have been performed under conditions not conducive to safe results.

Dr. H. J. Barnes reports[3] in Boston hospitals a relative humidity of thirty-one per cent, with an outside humidity of seventy-one, and says that "the influence of this excessively dry air on the respiratory tract cannot but be pernicious, in that it exhausts the watery flow from the lungs outward, thickening the excretions and interfering with the ciliary motion on lining membrane. Under these conditions, foreign matter, especially the pathogenic bacteria, is not expelled and the ordinary 'cold' beginning in the upper air passages terminates in a bronchitis." In this same article it is reported that the Bell Telephone Building in Boston is equipped with humidifiers by which six hundred gallons of water per day are evaporated into the air and a relative humidity of fifty-two and fifty-three is maintained. The result has been that among the operatives there has been a great diminution of colds.

The question of humidity has not been given due attention in homes and in schoolrooms. Some furnaces have water pans and in steam heated rooms the dwellers are accustomed to place pans of water on the radiators, but these are not found to be highly efficacious in raising the humidity, although they aid in a slight measure. Most rooms demand more moisture than can be evaporated from the small surface of water. "We sit out of doors in June in medium weight clothing when the temperature is sixty-five and a normal relative humidity of from sixty-five to seventy-five. Inside our houses in winter, with much heavier clothing, we require at least five degrees more of heat for comfort,

[2] Science XVI 953, December, 1902.

[3] The Influence of Relative Humidity, Medical Brief, August, 1904.

and often in steam heated apartments, fifteen degrees greater heat than the ideal June days is observed without consciousness of being excessively warm where the relative humidity is half or less than half that which nature ordinarily provides."[4]

This feature of air condition so universally neglected is presented with the hope that teachers and people generally may be interested.

[4]The Arid Atmosphere of our Houses in Winter. Dr. H. J. Barnes. Trans-American Public Health Association, 1897.

PHYSIOGRAPHY AS AN INTRODUCTION TO SCIENCE.

By a Teacher of Physiography.

It goes without saying that the fundamental aim in teaching any subject determines both the subject matter to be taught and the method of presenting it.

If physiography teachers can agree as to the real purpose of physiography in the high school curriculum, they will not differ widely as to subject matter and methods.

At present there seems to be unanimity on one point only, namely, that physiography belongs in the high school course.

I think most differences of opinion as to the time and place to be given to physiography can be traced back to a fundamental difference of viewpoint as to the purpose of the study in the high school. This difference of viewpoint may be summed up in the question: Should physiography be treated as a science, on a footing with chemistry, physics, and geology; or should it be made in considerable part an introduction to science?

If physiography is to be treated successfully as a science it must, in my opinion, come late in the course and be given a full year's time. The subject is too difficult for immature minds just beginning to reason. Its range of topics is too wide and its generalizations too broad for first or second year pupils. It is significant that Professor Cox of the Chicago weather bureau would not let his boy take physiography in the high school. He said it was too difficult a subject for first year pupils to bother with. One of Chicago's best geography teachers says she is free to admit she cannot teach seasons to first year pupils. She probably differs from most of us only in admitting her failure. She says pupils do acquire a correct verbal explanation of seasons, but that a little probing always shows a lack of correct or adequate ideas back of the words. It isn't well for a teacher's peace of

mind to do much probing. Occasionally pupils reveal what is really in their minds without probing. After flattering myself that a certain class had some very definite ideas on the weathering of granite, I once got this explanation of the process in an examination paper: "Granite is destroyed by having its felt spot eaten out by oxygen."

Physiography overlaps with other sciences at so many points that it can hardly be said to have any individuality. It seems to be a sort of eclective science, without any basic principle of its own.

Physiography touches astronomy at one of its most difficult points—the apparent path of the sun as seen from different latitudes at different times of the year, for it is the sun's course with reference to the horizon of different latitudes that determines seasons.

Physiography includes most of dynamic geology, and so much besides, that it is often classed as a department of geology.

Any adequate understanding of weathering, and the work of underground water, requires a considerable knowledge of chemistry.

To understand convection, rotational deflection, and the stratification of water deposits, the pupil must know important laws of physics.

Finally, our new eclectic science has incorporated into itself bodily the science of meteorology.

In the face of such generous overlapping with other sciences how can physiography claim individuality as a science? Evidently, it can establish its claim only by pointing to some underlying aim that has guided it, unconsciously perhaps, in the selection of material.

On what basis physiography can be considered a science, in the sense that astronomy, geology, chemistry, physics, and biology are sciences, I leave others to point out. I am only saying that if it is a science, it is a difficult science, to be taught in the senior year—and then a five months' course in geology followed by five months of meteorology, would cover the ground, without stretching the name physiography over the two subjects.

The key to the eclecticism of physiography is to be found in its original purpose as a high school study. I think I am right in saying that physiography came into the curriculum of academies and high schools as the science of the familiar—i. e., its

original aim was to explain to young pupils the more familiar and obvious phenomena of nature.

In keeping with this aim astronomy was called upon to explain day and night and the coming and going of the seasons, geology to explain the more noticeable land forms, and meteorology to explain the winds and the rain. The thread which held together these diverse topics was the fact that the phenomena explained either belonged to the immediate environment of the pupil, or were of a striking nature—such as earthquakes, volcanoes, and hurricanes.

Whatever it may be now, physiography was not at first a science, but an introduction to science based on the more striking and familiar processes of nature.

In the hands of department teachers and of the specialists who make our text-books and laboratory manuals physiography has grown increasingly difficult and more removed from the familiar and obvious in nature. The study of the more noticeable land forms—mountains, valleys, plains—no longer suffices. The pupil must now study in detail the evolution of land forms, as exhibited in contour maps. It is not enough now for the pupil to understand the weather elements separately, to know how the winds blow and why it rains. He must coördinate the weather elements into the difficult conception of climate, and compare the climates of different countries and consider the effects of climate upon plant and animal life and human occupations.

We have reached the parting of the ways in physiography. We must either transfer it to junior or senior year, as a full grown science, or restore it to something of its original status as an introduction to science, if we keep it in the first year.

I believe we should retain it in the first year, but consciously make it, to a greater extent than it is now, an introduction to science.

I do not mean, of course, that we should abandon physiography for a rambling course in elementary science. Let the study of land forms and weather elements still be our main object; but at the points where physiography touches other sciences let the teacher have time to give the pupil enough insight into those sciences to leave him with a desire for further acquaintance. Time so spent is well spent, even if fewer contour maps are studied and some topics set down in the text-book are omitted.

Let me illustrate by reference to two or three of these contact points.

Physiography touches astronomy in the study of seasons. Instead of plunging at once into the dry and perplexing subject of the relation of the sun to the horizon of different latitudes, let the pupil first study the earth as a planet, revolving, in common with other planets, around the sun—all moving in the same direction and on nearly the same level, but at different distances and speeds. Show him the size of the planets compared with the sun as a two-foot globe. Let him know about the rings of Saturn and the resemblances of Mars to the earth. Introduce him to the subjects of gravitation and centrifugal force by asking what holds the earth up, and whether there is any place—except the circus—where people stand with heads down.

Ask the pupils for proofs that the earth is spherical, and challenge the proofs given. If they say Magellan sailed around the earth and therefore it is round, ask if Magellan could have sailed around a stovepipe earth, or if a fly could crawl around a chalk box, and if the fly would be warranted in telling the other flies he had proved the chalk box round. Lead the pupils to see that Magellan's real proof was the gradual shifting of his horizon plane to the sky. Show them that by the same gradual tipping of a traveler's horizon toward the direction he is going the North Star rises as many degrees as one travels toward it, and that the size of the earth has thus been calculated.

Let the pupils figure out how long it would take a mile-a-minute express to cover the distance from the earth to the sun. When they have reduced ninety-three million minutes to years and got an answer of 176+, they will have a vivid and lasting impression of astronomical distances, and of the intensity of the sun's heat, that can reach across that space and bring a man to earth with sunstroke.

Finally, give the pupils pins and thread and direct them in the drawing of an ellipse to represent the earth's orbit with the sun at one focus. Have them mark the perihelion and aphelion ends of the orbit, and let them place the equinox and solstice dates at the proper points in the orbit. They will discover that the earth is nearer the sun in winter than in summer. This seeming paradox is your starting point for studying the real cause of seasons.

Such an astronomical introduction to the study of seasons may easily take two weeks' time. But, judging by the interest

of the pupil, I doubt if the time could be better spent in any other way. The pupil has had his eyes opened to the immensity of space and the wonders of astronomy, and he understands better man's place in nature. Such an opening of the eyes to the world we live in is highly cultural. Aside from its cultural effect upon the pupil, science is the gainer by this two weeks' course in astronomy. Not a few of the pupils decide then and there to choose astronomy as one of their studies in senior year. A school that takes up the study of seasons in some such way as this will always have an astronomy class of seniors—i. e., if I may judge by the experience of our school.

In the study of weathering physiography touches chemistry since oxygen and carbon dioxide are important agents of rock destruction.

The text-book used in Chicago high schools devotes twelve half lines to the work of oxygen and makes a single casual reference to carbon dioxide as a dissolving agent. But here is the teacher's opportunity to interest the pupil in chemistry. At our school we make the most of the opportunity, though, first and last, it takes nearly a week's time that must be stolen from text-book topics and contour work. We introduce the pupils not only to chemistry, but to the chemistry teacher as well. After a day's preparatory talk and discussion on the nature of chemistry, the pupils go to the chemical laboratory for a demonstration lecture by the chemistry teacher. There they learn how matter is supposed to be composed of molecules, and how eighty chemical elements suffice to form the myriad substances in the world—something as the twenty-six letters of the alphabet can be variously combined to form the quarter million words in the big dictionary. They learn that these elements have their habits of behavior toward each other, which it is the business of the chemist to discover. The difference between chemical compounds and mixtures is made clear to them through concrete illustrations.

Water is taken as their example of a compound. They see hydrogen, a gas that burns, and oxygen, a gas that makes things burn, unite with a violent explosion to form a liquid that puts out fire—as mysterious a transformation as any in the Arabian Nights! Later they see water separated again into its gases by an electric current—the gases that come off being duly tested.

Air is made their example of a chemical mixture, without union or change. They see oxygen burned out of a bottle of air,

by phosphorus, leaving the bottle four fifths full of a gas that puts out flame—nitrogen.

They learn that oxygen is the most abundant and most social of the elements, and that in combining with other substances it destroys them. They see wood, charcoal, sulphur, phosphorus, and iron wire burned in oxygen.

They learn that CO_2 is made in the laboratory by pouring an acid over marble or limestone and that one great source of the gas in nature is the decay of plants.

They see carbon dioxide extinguish flame, turn blue litmus red, and lime water milky. They discover that the breath contains carbon dioxide by seeing limewater turn milky as one of the pupils breathes into it through a tube.

They are told that CO_2 is not a poison, since we drink it in soda water, but that when breathed it smothers life—as it smothers the candle flame—the lungs being unable to get the oxygen away from the carbon.

Finally the pupils learn that CO_2 is heavier than air, (1) by seeing it poured down an inclined trough extinguishing candle flames as it goes; (2) by seeing it weighed against air in delicate scales.

For a day or two after the lecture the pupils are questioned regarding the various experiments and allowed to ask questions and make blackboard diagrams of the experiments. Finally they are required to write up the lecture fully with illustrative diagrams.

Judging by the open mouthed interest shown, the visit to the chemical laboratory is fairyland to a first year pupil. Perhaps the time could have been spent to better advantage in studying the migration of divides or the conditions of river piracy, but I doubt it.

The subject of weathering is resumed by reminding the pupils that they went to the chemical laboratory to get acquainted with oxygen and carbon dioxide. The class now readily understands how oxygen, with the help of moisture, can destroy wood and various minerals by a slow burning called decaying or rusting. Among the minerals so destroyed iron, the cement of red and yellow sandstones, and feldspar, the cement of granite are especially noticed.

By turning blue litmus red CO_2 acted as an acid. It is therefore destructive to lime, the cement of limestone, and marble. Most rain water that soaks into the earth contains oxygen ab-

sorbed from the air and carbon dioxide absorbed from the decaying grass and leaves at the surface of the earth. It is thus doubly armed for its work of rock destruction.

Our pupils are introduced to the subjects of air pressure and convectional winds by a visit to the physics laboratory—where they see that air has weight and presses in all directions, that heat expands all objects—solids, liquids, and gases—explicable only on the molecular theory of matter spoken of in the chemistry lecture—and that the unequal heating of liquids and gases starts currents.

But enough of detail! At the risk of tediousness I have tried to make clear what I mean by making physiography an introduction to science. If we are to keep the study in the first year I think that both the pupils and science would be gainers if we plan the course in a way to make much of the contact points between physiography and other sciences.

PRELIMINARY ESTIMATE OF PRODUCTION OF PORTLAND CEMENT IN 1910.

The production of Portland cement made a new high record in the year 1910. From statistics and estimates received by the United States Geological Survey from about twenty per cent of the companies manufacturing Portland cement, representing nearly half of the entire output of the country, it is estimated by E. F. Burchard of the Survey that the quantity of Portland cement manufactured in the United States in 1910 was between 73,500,000 and 75,000,000 barrels, as compared with 63,508,471 barrels produced in 1909—an increase of 10,000,000 to 12,500,000 barrels, or 15 to 20 per cent. The figures at hand are derived from all parts of the United States, and are therefore considered to be representative of the country at large rather than of any single section or district.

Alhough the average values for 1910 appear, from returns received thus far, to have been slightly higher than in 1909, prices were far from satisfactory, especially to the large manufacturers in the Lehigh Valley district and in certain of the Eastern States. The year 1911 opens with prices cut 5 to 10 cents a barrel lower than those prevailing in 1910. The construction of several new plants has been pushed during the year, and several plants that were under construction in 1909 became producers in 1910, so that the kiln capacity remains far in advance of the demand.

AN EXPERIMENTAL MICROCOSM.

By Edgar N. Transeau,
Eastern Illinois State Normal School.

The great food and energy cycle of living organisms has come to be an interesting and important topic in most courses in biology. The more recent text-books contain the familiar diagram in one form or another, which shows that green plants absorb certain inorganic substances and by the use of the sun's energy elaborate the food for all plants and animals; that this food is used either directly for the liberation of energy or temporarily stored in the form of more complex substances and protoplasm; also that the death of the plants and animals renders available these stores of food and energy for the bacteria and fungi, which in turn redistribute the energy and resolve the organic compounds into simpler substances, making them available for other cycles of transformation.

This concept is so fundamental to an understanding of the interrelations of organisms that an experimental demonstration which would enforce it upon the minds of the students seems most desirable. In devising an experiment to illustrate this principle the following factors of the food and energy cycle are essential:

(1) A sufficient quantity of the elements oxygen, carbon, hydrogen, nitrogen, phosphorus, sulphur, potassium, iron, calcium, magnesium, sodium, and chlorine in an available form, to permit their temporary storage in the organisms and in dead organic matter, and still have at all times an amount adequate for the immediate needs of the living plants and animals.

(2) Green plants which will multiply rapidly and grow vigorously at all seasons of the year.

(3) Sunlight sufficient for photosynthesis, but not too intense for the rapid growth of bacteria and fungi.

(4) Animals that can derive an adequate food supply directly from the plants.

(5) Bacteria and fungi.

(6) Moderate temperatures.

Aquatic plants and animals seem to meet these requirements to the best advantage. In laboratory practice I have found that of the available plants, the very common alga, Scenedesmus can be depended upon for the continuous growth throughout the year under laboratory conditions. The common goldfish will live

and thrive on this plant as a food at least for several months. Accordingly the following experiment was set up last year and was found to work successfully throughout the remainder of the school year—seven months.

A cylindrical museum jar 43cm high and 14cm in diameter, having a total capacity of six and a quarter liters, was half filled with a mixture of three parts of tap water and one part of Moore's solution. The tap water has the following composition:

Sodium nitrate	.66mg.
Sodium chloride	.86mg.
Sodium sulphate	3.08mg.
Magnesium sulphate	.90mg.
Magnesium carbonate	8.38mg.
Iron carbonate	.04mg.
Calcium carbonate	124.80mg.
Silica	1.70mg.
Water	1000.00cc.

Moore's solution for the growing of algae is made as follows:

Ammonium nitrate	.5g.
Potassium phosphate	.2g.
Magnesium sulphate	.2g.
Calcium chloride	.1g.
Iron sulphate	Trace
Distilled water	1000cc.

To this was added 500cc. of a pure culture of Scenedesmus quadricauda (Turp) Breb. The algae multiplied rapidly and at the end of ten days a goldfish 6cm. long was added to the aquarium. The ground glass stopper was then put on the jar and sealed *airtight* with laboratory cement. The jar was placed near a west window but screened from direct sunlight at all times. The jar was sealed on January 1, 1910 and was still apparently in good condition on July 28, when an accident—allowing the jar to stand in full sunlight for a day—brought the experiment to an end by killing the fish.

PROBLEM DEPARTMENT.

BY E. L. BROWN,

Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

229. *Proposed by E. B. Escott, Ann Arbor, Mich.*

Solve: $x^2 - yz = a$ (1),
$y^2 - zx = b$ (2),
$z^2 - xy = c$ (3).

I. Solution by N. Anning, Chilliwack, B. C.

From square of (1) subtract product of (2) and (3), we have

$a^2 - bc = x(x^3 + y^3 + z^3 - 3xyz) = x(x + y + z)\ (x^2 + y^2 + z^2 - xy - xz - yz) = x(x + y + z)\ (a + b + c)\ldots\ldots$ (4)

Similarly,

$b^2 - ca = y(x + y + z)\ (a + b + c)\ldots\ldots$ (5)

$c^2 - ab = z(x + y + z)\ (a + b + c)\ldots\ldots$ (6)

Adding (4), (5), and (6) we have

$(x + y + z)^2\ (a + b + c) = a^2 + b^2 + c^2 - ab - ac - bc.$

$\therefore\ (x + y + z)^2\ (a + b + c)^2 = a^3 + b^3 + c^3 - 3abc,$

and $(x+y+z)\ (a+b+c)=(a^3+b^3+c^3-3abc)^{\frac{1}{2}} \equiv K\ldots.$ (7)

From (4) and (7) $x=\dfrac{a^2-bc}{K}$, also $y=\dfrac{b^2-ca}{K}$, and $z=\dfrac{c^2-ab}{K}$

II. Solution by T. E. Peters, Denton, Texas.

Let $x=my$. Substitute this value of x in (1), (2), (3).

From (1) and (2) $y^2 = \dfrac{am-b}{m^3-1}\ldots.$ (4)

From (2) and (3) $y^2 - 2b + \dfrac{b^2}{y^2} = cm^2 + m^2y^2\ldots\ldots$ (5)

From (5) and (4) $m=\dfrac{a^2-bc}{b^2-ac}\ldots\ldots$ (6)

From (4) and (6) $y^2=\dfrac{(b^2-ac)^2}{a^3+b^3+c^3-3abc}=\dfrac{(b^2-ac)^2}{K^2}.$

$\therefore y=\dfrac{b^2-ac}{K},\ x=\dfrac{a^2-bc}{K},\ z=\dfrac{c^2-ab}{K}.$

III. Solution by I. L. Winckler, Cleveland, O., and A. L. McCarty, Ann Arbor, Mich.

From the given equations

$$(x^2-yz)^2-(y^2-zx)(z^2-xy)=a^2-bc$$

$$\text{or } x\ (x^3+y^3+z^3-3xyz)=a^2-bc$$

$$\therefore\ \frac{x}{a^2-bc}=\frac{1}{x^3+y^3+z^3-3xyz}=r$$

Similarly, $\dfrac{y}{b^2-ca}=r$, and $\dfrac{z}{c^2-ab}=r$

$$\therefore \frac{x}{a^2-bc}=\frac{y}{b^2-ca}=\frac{z}{c^2-ab}=\frac{\sqrt{x^2-yz}}{\sqrt{(a^2-bc)^2-(b^2-ca)(c^2-ab)}}$$

$$=\frac{\sqrt{a}}{\sqrt{a(a^3+b^3+c^3-3abc)}}=\frac{1}{K}$$

$$\therefore x=\frac{a^2-bc}{K},\ y=\frac{b^2-ca}{K}$$

$$z=\frac{c^2-ab}{K}$$

230. *Proposed by Hilda R. Stice, Petersburg, Ill.*

Solve: $x^2+y=7$ (1),
$y^2+x=11$ (2).

I Solution by C. F. Northrup, Waterbury, Conn., and G. M. Weld, Watertown, Conn.

Eliminating y, we have $x^4-14x^2+x+38=0$...... (3)

Whence $x=2$ and $x^3+2x^2-10x-19=0$. From the latter by Horner's method we find $x=3.131, -1.849, -3.283$.

Hence $y=-2.803, 3.581, -3.778$.

II. Solution by Laura S. Seals, Cedar Falls, Iowa.

Adding (1) and (2), $x^2+x+y^2+y=18$...... (3)

Oh but, Laura,

Multiplying (3) by 4 and adding 2, we have

$(2x+1)^2+(2y+1)^2=74=25+49$.

$1^2+8^2=7^2+4^2$.

Now since the sum of two squares cannot equal the sum of two other or different squares, and since $y^2+x>x^2+y$,

$\therefore (2y+1)^2=49$. $\therefore y=3$ or -4.

Also $(2x+1)^2=25$. $\therefore x=2$ or -3.

The negative values do not satisfy the given equations.

III. From Fisher and Schwatt's Text-book of Algebra, Part I, page 376.

Subtracting (1) from the product of (2) by x,

$xy^2-y=11x-7$...... (3)

Adding (3) to twice (2),

$xy^2-y+2x+2y^2=11x+15$,

or $y^2(x+2)-y=9x+15$...... (4)

Solving (4) for y,

$$y=\frac{1}{2(x+2)}\pm\left(\frac{9x+15}{x+2}+\frac{1}{4(x+2)^2}\right)^{\frac{1}{2}}=\frac{1}{2(x+2)}\pm\frac{6x+11}{2(x+2)}\ \ldots\ldots \quad (5)$$

From (5), taking the sign + between the fractions, we have $y=\frac{3x+6}{x+2}=3$; taking the sign − between the fractions, $y=-\frac{3x+5}{x+2}$. Substituting 3 for y in (2), $x=2$. Therefore one solution is 2, 3. If we substitute $-\frac{3x+5}{x+2}$ for y in either (1) or (2), we are led to the cubic equation $x^3+2x^2-10x=19$, which can be solved by Horner's method.

231. *Proposed by Richard Morris, New Brunswick, N. J.*

Three men and a boy agree to gather the apples in an orchard for \$50. The boy can shake the apples in the same time that the men can pick them, but any one of the men can shake them 25 per cent faster than the other two men and boy can pick them. Find the amount due each.

I. Solution by H. E. Trefethen, Kent's Hill, Me., and T. M. Blakslee, Ames, Iowa.

x = the part of a man's work the boy does.
k = number bushels apples the man shakes off in a day.
kx = number bushels apples the boy shakes off in a day
$kx/3$ = number bushels apples each man picks up in a day.
$kx^2/3$ = number bushels apples the boy picks up in a day.

$$2kx/3 + kx^2/3 = 4k/5.$$

Whence $x = 0.843909$, about 27/32 or 173/205.

Boy's share of pay = \$10.976, each man's share = \$13.008.

II. Solution by O. L. Brodrick, Upper Sandusky, Ohio.

Suppose a man does x times as much work as a boy.

By the first condition,

shaking the apples : picking them up $= 1 : 3x$.

By the second condition,

shaking the apples : picking them up $= 4x/5 : 2x + 1$.

$\therefore 1 : 3x = 4x/5 : 2x + 1$ or $12x^2 - 10x - 5 = 0$. $\therefore x = 1.185$.

$\therefore$ The money is divided into parts proportional to 1, 1.185, 1.185, and 1.185.

$\therefore$ The boy receives \$10.98— and each man receives \$13.01—.

232. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

On one side of an equilateral triangle describe outwardly a semicircle. Trisect the arc and join the points of division with the vertex of the triangle. Find the ratio of the segments of the diameter.

I. Solution by N. Anning, Chilliwack, B. C., and M. W. Wilson, Richmond, Ky.

Let the semicircle be drawn on BC of equilateral triangle ABC. Let D and E be the points of trisection of the arc, D being nearest B. Let AE and AD intersect BC at F and G, respectively.

$\triangle$ CEF is similar to $\triangle$ AFB.

$\therefore$ CF : BF = CE : AB = 1 : 2.

Similarly BG : CG = 1 : 2.

$\therefore$ CF = FG = BG.

II. Solution by the proposer.

Let the semicircle on BC be trisected at D, E, and O the center. Join AO and draw DF perpendicular to BO. BC is cut by AD at H, and by AE at I. BOD is an equilateral triangle and 2DF = AO. Triangles DFH and AOH are similar. 2FH = HO = BO/3. Therefore BH = HI = IC = BC/3.

III. Solution by C. A. Perrigo, Dodge, Neb.

Let ABC be the equilateral triangle, CDEB the semicircle with equal arcs CD, DE, and EB. Let AD and AE intersect at BC in F and G respectively. Let O be center of circle.

Prove CF = FG = GB.

Clearly $\triangle$ ACD = $\triangle$ ABE. $\therefore \angle$ CDA = $\angle$ BEA.

$\therefore \triangle$ CFD = $\triangle$ BGE, and CF = BG. $\therefore$ OF = OG.

Since $\triangle$ OGE is similar to $\triangle$ ABG,

OE : AB = OG : GB.

Since AB equals the diameter BC, OE = ½AB.

$\therefore$ OG = ½GB. But OG = ½FG.

$\therefore$ CF = FG = GB.

233. *Selected.*

If AD, BE, CF are the altitudes of the triangle ABC and H their point of intersection, prove

(1) the triangles AFE, CED, and BDF are similar,

(2) BD·DC = DF·DE = DH·DA,

(3) circumcircles of triangles AHB, AHC, BHC are equal,

(4) the radius of the circle DEF is one half that of the radius of the circle ABC.

(1) *Solution by J. M. Townsend, South Braintree, Mass., and I. L.* Winckler, Cleveland, O.

AEHF is inscriptible; $\therefore \angle$ AEF $= \angle$ AHF $= \angle$ CHD $= 90° - \angle$ HCD $= \angle$ B.

$\angle$ A is common to triangles ABC and AEF. $\therefore \triangle$ ABC is similar to $\triangle$ AEF. Similarly BDF and DEC are similar to ABC.

$\therefore$ AEF, BDF, and DEC are similar.

(2) *Solution by H. C. Willett, Los Angeles, Cal., and T. M. Blakslee, Ames, Iowa.*

From the similar triangles CED and FBD we have DB·DC = DF·DE; from the similar triangles DHE and DFA we have DF·DE = DA·DH.

Solution by H. E. Trefethen, Kent's Hill, Me.

Right triangles HAF, HCD are similar. Produce AD to cut the circle ABC at I. Then DCI (BCI) = BAI (FAH) = DCH. Hence ID = DH. Thus BD·DC = ID·DA = DH.DA. Again BDF and CED are similar, BD : DF = DE : DC, and BD·DC = DF·DE. Therefore BD·DC = DF·DE = DH·DA.

(3) *Solution by T. M. Blakslee, Ames, Iowa.*

If R_1, R_2, R_3 be the radii of the circumcircles of AHB, AHC, BHC, HA·HB $=2R_1$·HF and HA·HC $= 2\ R_2$·HE. Dividing we have

$$\frac{R_1}{R_2}=\frac{HE\cdot HB}{HC\cdot HF}\quad HE\cdot HB=HC\cdot HF \text{ since BCEF is inscriptible.}$$

$\therefore R_1 = R_2$. Similarly $R_1 = R_3$. $\therefore R_1 = R_2 = R_3$.

Solution by H. C. Willett, Los Angeles, Cal.

At M, N, L, the mid-points of AH, CH, and BH respectively, draw perpendiculars intersecting at O, O′, O″, the circumcenters of AHB, AHC, and BHC respectively. Draw OH, O′H, and O″H. In the circle AHB, $\angle$ ABH $= \angle$ MOH, each measured by one half the arc AH. Similarly in circle AHC, $\angle$ ACH $= \angle$ MO′H. But $\angle$ ABH $= \angle$ ACH. $\therefore \angle$ MOH $= \angle$ MO′H and OH = O′H. Similarly OH = O″H. $\therefore$ OH = O′H = O″H.

Solution by H. E. Trefethen, Kent's Hill, Me.

Produce HF to cut the circle ABC at K. Angles FAK (BAK) = BCK (DCH) =FAH. Hence FH = FK and triangles AHB = AKB. Hence circles AHB = AKB = ABC. Likewise for circles BHC and AHC. Therefore the circumcircles of triangles AHB, AHC, BHC, ABC are equal.

(4) *Solution by H. E. Trefethen, Kent's Hill, Me.*

By (1) and problem 228 the circle DEF bisects AB, BC, CA. Call the midpoints O, P, Q. Triangle OPQ is similar to ABC. AB = 2PQ, and AC = 2PO. But AB·AC = 2R·AD and PO·PQ = r·AD. Whence R = $2r$.

Solution by T. M. Blakslee, Ames, Iowa.

If altitude of DEF from D be DK,

DE·DF $= 2r$·DK $= 2r$·DF·$\sin$ 2C $= 2r$·DF·$2\sin C\cos C$.

$$AB\cdot AC=\frac{DB\cdot DC}{\cos B\cdot\cos C}=\frac{DE\cdot DF}{\cos B\ \cos C}=2R\cdot AD$$

$$\therefore\ \frac{R}{2r}=\frac{DF}{DA}\cdot\frac{\sin C}{\cos B}.\quad \text{From } \triangle DAF, \text{ we have } DF\sin C=AD\cos B$$

$\therefore R = 2r$.

Solution by I. L. Winckler, Cleveland, O., and H. C. Willett, Los Angeles, Cal.

The circumcircle of DEF bisects HA, HB, and HC. Let this circumference cut HB at O. Then $\angle$ DFO $= \angle$ DEO $= 90° -$ B.

$\therefore \angle$ OFB $=$ C $-(90°-$B$) =$ B $+$ C $- 90° = 90° -$ A $= \angle$ ABE.

$\therefore$ O is the midpoint of HB. Similarly the circumcircle of DEF bisects

HA and HC. Suppose it intersects HA and HC at P and R, respectively. Then $\triangle$ OPR $= \frac{1}{4}$ $\triangle$ ABC. Let R and R′ be the radii of the circumcircles of ABC and OPR, respectively.

$R = \frac{abc}{4s}$ and $R' = \frac{opr}{4s'}$ where a, b, c, s and o, p, r, s' are the sides and areas of the triangles, respectively.

$$o = \tfrac{1}{2}b,\ p = \tfrac{1}{2}a,\ r = \tfrac{1}{2}c,\ s' = \frac{s}{4}.$$

$$\therefore\ R' = \frac{opr}{4s'} = \frac{\frac{1}{2}a \cdot \frac{1}{2}b \cdot \frac{1}{2}c}{4 \cdot \frac{1}{4}s} = \frac{abc}{8s} = \tfrac{1}{2} \cdot \frac{abc}{4s} = \tfrac{1}{2}R.$$

CREDITS FOR SOLUTIONS RECEIVED.

Geometry 219. M. H. Pearson. (1)
Algebra 221. J. F. Taylor. (1)
Algebra 224 N. Anning, H. M. Monroe, T. E. Peters, G. M. Weld, H. C. Willett. (5)
Algebra 225. N. Anning, G. I. Hopkins, H. C. Willett. (3)
Geometry 226. N. Anning, H. C. Willett. (2)
Geometry 227. N. Anning. (1)
Geometry 228. N. Anning (1).
Algebra 229. N. Anning, T. M. Blakslee, Nans Mahoney, A. L. McCarty, T. E. Peters, H. E. Trefethen, I. L. Winckler. (7)
Algebra 230. T. M. Blakslee, E. R. Gross (2 solutions), J. E. Helman, E. E. Matthews, C. F. Northrup, C. A. Perrigo, T. E. Peters, Laura S. Seals, J. M. Townsend, H. E. Trefethen, G. M. Weld, Jas. A. Whitted, I. L. Winckler. (14)
Algebra 231. T. M. Blakslee, O. L. Brodrick, Richard Morris, H. E. Trefethen, I. L. Winckler. (5)
Geometry 232. N. Anning (2 solutions), T. M. Blakslee, O. L. Brodrick, D. Lawrence, R. H. Marshall, A. L. McCarty, E. Morgan, C. A. Perrigo, E. Petit, H. E. Trefethen, H. C. Willett, M. W. Wilson, I. L. Winckler. (14)
Geometry 233. T. M. Blakslee, J. M. Townsend, H. E. Trefethen, H. C. Willett, I. L. Winckler. (5)
Total number of solutions, (59).

PROBLEMS FOR SOLUTION.

Algebra.

239. *Proposed by E. R. Gross, Long Pine, Nebr.*

Solve: $x+2y+3z+4w=30$ (1).
$2x+3y+4z+5w=40$ (2).
$3x+4y+5z+6w=50$ (3).
$4x+5y+6z+7w=60$ (4).

240. *Proposed by F. E. Tuck, Napa, Cal.*

Derive the formula used in playing the following card trick.

Take out the joker and shuffle the deck. Look at the top card and place it face down on the table. Suppose it is a six spot. Then deal from the deck the next card, place it on the six spot and count seven. Deal the next and count eight; the next, nine; the next, ten.

Look at the following card and use it as the bottom of a new pile building from the number of its spots up to ten as before. Continue thus until the

cards are all arranged in piles, with perhaps some left over. All face cards are considered as ten spots and, of course, should one fall as the first card of any pile that pile would be complete.

Let $x =$ the number of piles.

$y =$ the number of cards remaining after the last pile is completed.

$S =$ the sum of the spots on the bottom cards of all the piles (face cards counting as ten spots).

$11(x-5) + 3 + y = S.$

Geometry.

241. *Proposed by G. V. Kinney, Buffalo, Minn.*

In the semicircle ABCD express the diameter AD in terms of the chords AB, BC, CD.

242. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

If a, b, c are the sides of a triangle and $5(a^2 + b^2 + c^2) = 6(ab + bc + ca)$, show that the incircle passes through the centroid of the triangle.

243. *Selected.*

If a circle passing through one of the angles A of a parallelogram, ABCD intersect the two sides AB, AD again in the points E, G and the diagonal AC again in F, then

$$AB \cdot AE + AD \cdot AG = AC \cdot AF.$$

GRAPHICAL SOLUTION OF QUADRATIC WITH COMPLEX ROOTS.

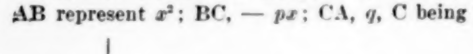
By T. M. Blakslee,
Ames, Iowa.

Graphical Solution of Quadratic with Complex Roots, by T. M. Blakslee, Ames, Iowa.

Professor Runge's method in the January number was of much interest. Seemingly, it is not applicable to the equations treated here by an original method, that may be of interest in this connection.

$x^2 - px + q = 0$ (1) is the equation with the roots $a + bi$ and $a - bi$.

Let AX and AX' be the positive and negative parts of the ray of reals. AB represent x^2; BC, $-px$; CA, q, C being in X'X as q is real.



Triangle ABC isosceles. *Geometric proof.* AD representing x bisects angle BAX and is parallel to CB $\therefore$ AC $=$AB. *Algebraic proof.* (1) is $[(x-a) - bi]\,[(x-a) + bi] = 0$, $x^2 - 2ax + (a^2 + b^2) = 0$. $\therefore$ numerically $q = a^2 + b^2 = x^2$, and AC $=$ AB. The following figure is for $x^2 - 2x + 5 = 0$ though the general values are also given.

By the usual method construct $CG = \sqrt{5}$, $CH = 2\sqrt{5}$, $CA = 5$. With C and A as centers and radii CH and AC mark arcs cutting at B. On the bisector of BAX lay off $AD = CG$.

AD is the stroke representing $x_1 = a + bi$. Here $x_1 = 1 + 2\sqrt{-1}$. $x_2 = a - bi$ is easily constructed.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Our readers are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Questions and Problems for Solution.

43. *Proposed by J. C. Packard, Brookline, Mass.*

A right circular cylinder, 2″x2″, specific gravity 0.7, floats in fresh water with its axis horizontal. How much must the cylinder be shortened to make it float upright?

44. *From an examination paper of Morris High School, New York.*

In the course of a stream is a waterfall 22 ft. high. It is shown by measurement that 450 cu. ft. of water per second pour over it. How many foot-pounds of energy could be obtained from it? What horse-power? What becomes of this energy if not used in driving machinery?

PHYSIOGRAPHY.

Harvard University, June, 1905.

Answer Four Questions.

1. State and explain the causes of ocean currents.
2. Describe two land forms that are produced by the action of the winds.
3. Describe with examples a river that receives more waste than it is able to transport. Under what conditions may a river receive so much waste?
4. Describe the forms and drainage of a glaciated peneplain—that is, a region of gently undulating form which has been subjected to glaciation.
5. Describe a typical case of the diversion of the upper part of one river by another. State three ways in which such a diversion can be recognized.

CHEMISTRY, JUNE, 1910.

The four starred questions must all be answered. Of the others, answer only three.

*1. Explain carefully an experiment for determining the atomic weight or the combining weight of zinc.

*2. Complete the following equations, using formulae:

Sodium carbonate + hydrochloric acid (excess) = ?
(Hot) zinc + water (vapor) = ?
Barium chloride + silver nitrate = ?

*3. How many cubic centimeters of ammonia gas, measured under standard conditions, could be obtained from ten grams of ammonium sulphate?

$H=1 \qquad N=14 \qquad O=16 \qquad S=32$

One liter of ammonia at 0° and 760 mm. weighs 0.76 gram.

*4. Define and explain the terms *element, compound, atom, molecule.*

5. Explain experiments to determine whether a compound—
   (a) contains water of crystallization;
   (b) is efflorescent;
   (c) is deliquescent;
   (d) ionizes on dissolving in water.

6. (a) Explain what is meant by *atomic weight.*
   (b) Explain what is meant by the *molecular weight* of a gas.

7. Hydrogen sulphide burns in an excess of oxygen to form sulphur dioxide and water vapor. What are the relations by volume between the hydrogen sulphide, the oxygen used, and the sulphur dioxide and water vapor produced?

8. How much silver could be deposited electrolytically by a quantity of electricity sufficient to deposit ten grams of copper?

$Ag=107.9 \quad Cu=63.6$

9. Give three general methods for making the nitrate of a metal. Illustrate each method by one equation.

10. What is lime? How is it made commercially? (Write the equation.) Explain two uses to which it is put.

APPARATUS FOR CONCURRING FORCES.

By Irving W. Horne, High School, Lynn, Mass.

School Science and Mathematics for January, 1908, contained a picture of apparatus constructed by Walter D. Bean of Chicago Heights, Ill., for demonstrating concurring forces, with a statement of explanation. I inclose a photograph of apparatus recently constructed for the same purpose by Charles S. Jackson, principal of the English High School, Lynn, Mass. In place of the usual spring balances, weights are attached to the ends

of the concurring threads after the threads have been passed through appropriately mounted pulleys. Frequent holes in the edge of the circular top allow much freedom in locating the wires which support the pulleys. By locating the pulleys appropriately and by making appropriate selections of weights, any desired angles may be formed by the concurring threads. The friction of the sheaves is completely overcome by tapping the circular top gently. The height of the apparatus is about twelve inches. The weights are easily adjusted, as the bottom weight on each thread is the only one which needs to be tied, additional weights being held by passing the thread around their tops.

ARTICLES IN CURRENT MAGAZINES.

Psychological Clinic for January: "The Fundamental Expression of Retardation," Rowland P. Falkner, Ph.D.; "Criminals in the Making," Lightner Witmer, Ph.D.; "Age per Grade of Truant and Difficult School Boys," Walter S. Cornell, M.D.

Nature Study Review for January: "Three Types of City Gardens," Alice Rigden; "Course in Nature Study, Eugene Field School, St. Louis," W. J. Stevens; "A Campaign against Flies;" "From School to Home," Fred L. Charles; "Nest Boxes for Woodpeckers," Frank C. Pellett; "Nature Calendars," Chester A. Mathewson.

Mining Science for January 12: "A Florida Phosphate Mine's Aerial Tramway," Frank C. Perkins; "Present Mining Conditions in Nicaragua," T. Lane Carter; "The Production and Uses of Zinc Dust," Paul Speier; "Germany's Potash Deposits and Mines," Robert J. Thompson.

Popular Astronomy for February: Frontispiece, Members at the August, 1910, Meeting of the Astronomical Society, Plate III; "The Measurement of the Light of Stars with a Selenium Photometer, Part II," Joel Stebbins; "A New Star in Lacerta," Plate IV, H. C. Wilson; "Note on the Spectrum of Nova Lacertae," Plate V, W. H. Wright; "The D. O. Mills Expedition to the Southern Hemisphere," W. W. Campbell; "A Method of Identifying the Satellites of Saturn," Willis L. Barnes; "Spectroscopic Observations of the Rotation of the Sun," Plate VI, Jennie B. Lasby; "The Solar Eclipse of April 28, 1911," Wm. F. Rigge, S. J.; "The Infinitude of the Universe," Frederick C. Leonard; "Halley's Comet: The Romance of Its Past," Irene E. T. Warner.

Sibley Journal of Engineering for January: "Systems of Wage Payment," C. B. Auel; "Products of an Up-to-date Cable Factory," H. W. Fisher; "The Engineering Research Department of Sibley College," Test of a Parsons Type Steam Turbine, R. C. Carpenter.

American Forestry for January: "Lessons from the Forest," by Edwin R. Jackson (with fourteen illustrations from photographs of the United States Forest Service); "Forestry Progress in New Hampshire," by W. R. Brown (with illustrations from photographs and a map); "The Lake States Fire Conference;" "Lumbermen and Forest Legislation," by Thornton A. Green; "Railways and Forest Protection," by R. H. Aishton; "The Protection of Forests from Fire," by Henry S. Graves (Part V—Conclusion. With two illustrations); "Prevention of Forest Fires in Minnesota," by C. C. Andrews.

Photo-Era for February: Beside the three dozen *achmioble* illustrations are the following: "In the Good Old Winter Time," Julian A. Dimrock; "The Lantern at Home," C. H. Claudy; "Some Successful Lantern-slide Toners, and How to Use Them," T. Thorne Baker; "Picture-Making in the Snow," Will Cadby; "The Eastman Advertising Competition," Malcolm Dean Miller.

Journal of Geography for January: "A Comparison of Trans-Appalachian Railroads," A. E. Parkins; "Geographic Influences in the Development of New York State," R. H. Whitbeck; "The World's Great Rivers: The Volga," Frederick Homburg; "Notes on Economic Geography," E. V. Robinson.

Education for January: "The Lesson of the State Universities," Elmer E. Brown; "The Duty of New England at the Present Time with Reference to the Endowed Colleges and Public Schools," Thomas Augustus Jaggar, Jr.; "The Training of College Bred Teachers," Paul H. Hanus; "What the Schools Need," Randall J. Condon; "The Certification of High School Teachers," David Snedden.

School World for January: "The Calculation of a Square Root" (illustrated), by T. Percy Nunn; "Secondary Education in New Zealand;" "The More Recent Developments of Education;" "Ocean Currents: Their Relation to One Another," by W. J. Humphreys; "Handwork in Relation to Science Teaching: Manipulative Skill of the Teacher," by G. H. Woollatt.

School Review for January: "*Parens Iratus*: His Cause and Cure," William McAndrew; "A Study of High School Grades," Franklin W. Johnson; "The Financial Administration of Student Organizations in Secondary Schools," Alva W. Stamper; "Summer Apprenticeship in the Boston High School of Commerce," Winthrop Tirrell; "Vocational Guidance," Stratton D. Brooks; "Vocational Guidance and Public Education," Paul H. Hanus.

Psychological Clinic for December: "The Nurse as a Municipal Officer," Walter S. Cornell, M.D.; "A Simple System for Discovering Some Factors Influencing Non-promotion," Leonard P. Ayres, Ph.D.; "The Irrepressible Ego," Lightner Witmer, Ph.D.

INTERNATIONAL ATOMIC WEIGHTS.

The international committee consisting of William Ostwald, F. W. Clarke, G. Urbain, and T. E. Thorpe has reported as follows on the atomic weights of the elements:

ELEMENT.	SYMBOL.	ATOMIC WEIGHT.	ELEMENT.	SYMBOL.	ATOMIC WEIGHT.
Aluminum	Al	27.1	Molybdenum	Mo	96.0
Antimony	Sb	120.2	Neodymium	Nd	144.3
Argon	A	39.88	Neon	Ne	20.2
Arsenic	As	74.96	Nickel	Ni	58.68
Barium	Ba	137.37	Nitrogen	N	14.01
Bismuth	Bi	208.0	Osmium	Os	190.9
Boron	B	11.0	Oxygen	O	16.0
Bromine	Br	79.92	Palladium	Pd	106.7
Cadmium	Cd	112.40	Phosphorus	P	31.04
Caesium	Cs	132.81	Platinum	Pt	195.2
Calcium	Ca	40.09	Potassium	K	39.10
Carbon	C	12.0	Praseodymium	Pr	140.6
Cerium	Ce	140.25	Radium	Ra	226.4
Chlorine	Cl	35.46	Rhodium	Rh	102.9
Chromium	Cr	52.0	Rubidium	Rb	85.45
Cobalt	Co	58.97	Ruthenium	Ru	101.7
Columbium	Cb	93.5	Samarium	Sa	150.4
Copper	Cu	63.57	Scandium	Sc	44.1
Dysprosium	Dy	162.5	Selenium	Se	79.2
Erbium	Er	167.4	Silicon	Si	28.3
Europium	Eu	152.0	Silver	Ag	107.88
Fluorine	F	19.0	Sodium	Na	23.0
Gadolinium	Gd	157.3	Strontium	Sr	87.63
Gallium	Ga	69.9	Sulphur	S	32.07
Germanium	Ge	72.5	Tantalum	Ta	181.0
Glucinum	Gl	9.1	Tellurium	Te	127.5
Gold	Au	197.2	Terbium	Tb	159.2
Helium	He	3.99	Thallium	Ti	204.0
Hydrogen	H	1.008	Thorium	Th	232.4
Indium	In	114.8	Thulium	Tm	168.5
Iodine	I	126.92	Tin	Sn	119.0
Iridium	Ir	193.1	Titanium	Ti	48.1
Iron	Fe	55.85	Tungsten	W	184.0
Krypton	Kr	82.92	Uranium	U	238.5
Lanthanum	La	139.0	Vanadium	V	51.06
Lead	Pb	207.10	Xenon	Xe	130.2
Lithium	Li	6.94	Ytterbium	Yb	172.0
Lutecium	Lu	174.0	Yttrium	Yt	89.0
Magnesium	Mg	24.32	Zinc	Zn	65.37
Manganese	Mn	54.93	Zirconium	Zr	90.6
Mercury	Hg	200.0			

SCIENTIFIC STUDY OF EDUCATION IN BIOLOGY—BIBLIOGRAPHY.

Under this caption there will be published from time to time a list of books and papers believed to be of interest to those interested in the subject. This is done as a part of the work of the committee appointed by the Biology Section of the Central Association for the purpose of encouraging research in the pedagogy of biology.

Three classes of titles will be included as follows: (1) text-books and other works of general interest, but bearing upon the subject, (2) investigations the subject matter of which is not biological but which are of interest to biologists because the method may be applicable in biology and, (3) investigations in the pedagogy of biology. It is hoped to make the third division complete; in the other two only the most important titles can be included.

It is hoped that members of the section, authors of papers, and publishers will coöperate by calling to the attention of the committee such papers as might not otherwise be noted.

McAuley, Faith.

Result of an Experiment to Determine Content and Appeal of First-Year Science. School Science *11*:14-15. Jan., 1911.

Presents briefly a method of determining suitability of material to stage of development of pupils. Capable of adaptation to any year of the school. The character of the material chosen for this test is not indicated in detail.

Tower, Willis E.

An Experiment: the Teaching of High School Physics in Segregated Classes. School Science *11*:1-6. Jan., 1911.

An experiment with quantitative results upon a very interesting subject. Method and some of the conclusions equally applicable in other sciences.

Eikenberry, W. L., and others.

Report of the Committee on the Experimental Investigation of the Teaching of Biology. School Science *11*:28-31. Jan., 1911.

A report presented to the Biology Section of the C. A. S. & M. T. at the meeting for 1910 and adopted by the section as its expression.

Johnson, F. W.

A Study of High School Grades. School Rev. *19*:13-24. Jan., 1911.

An illuminating study of the extraordinary variation of grading to be found in a single school, and in some cases within a department. Variation doubtless due to many causes prominent among which is differences in standards.

Gilbert, J. P.

An Experiment on Methods of Teaching Zoölogy. Jour. of Ed. Psychol. June, 1910. Pp. 321-332.

A preliminary report. A comparison of applied science with pure science as a point of view and source of supplementary material, using the parallel class method of investigation. A later report of the same work will be found in SCHOOL SCIENCE AND MATHEMATICS, March, 1911.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.

The second general meeting of the Southern California Science and Mathematics Association for 1910 was held at Pasadena Hall, Throop Polytechnic Institute, Pasadena, December 3, 1910. A large and enthusiastic crowd of teachers took part in the meeting and listened to a very excellent program. Chas. E. St. John, of the Mt. Wilson Observatory Staff, gave an illustrated address on the solar work of the observatory, in sight of which the meeting was held. This observatory, supported by Andrew Carnegie, is located on Wilson Peak which rises six thousand feet above Pasadena. Dr. George H. Kress, of the College of Medicine of U. S. C., gave an illustrated talk on the Prevention of Disease—Its Place and Study in Our Schools. Ralph Arnold, Ph.D., addressed the association on the geology of Southern California. A resolution was adopted urging Congress to make an appropriation of $75,000 to the Bureau of Education for the study of special school problems.

The following officers of the general association were elected for the year 1911: President, W. H. Snyder, Hollywood University High School; Vice-President, F. P. Brackett, Pomona College; Secretary-Treasurer, George C. Bush, South Pasadena Public Schools.

The mathematics section held an afternoon meeting with the following program: Calculation of Logarithms, G. A. L'Hommede; The New Requirement in Algebra, J. M. McPherron; Ratio, Proportion and Variation, Prof. Paul Arnold. The following officers were elected for this section: President, J. M. McPherron, Los Angeles High School; Vice-President, H. C. Fall, Pasadena High School; Secretary, Agnes Wolcott, Santa Monica High School.

The other sections elected officers as follows: Physics-Chemistry: President, W. K. Gaylord; Secretary, George Mitchell; Earth Science: President, W. A. Fiske; Secretary, Gertrude Ticknor; Biology: President, A. A. Hummel; Vice-President, Olga Tarbell; Secretary, A. C. Life. A pleasant feature of the meeting was the luncheon at Throop Academy and an automobile ride about the city. The next meeting will be held in April.

George Bush, *Secretary-Treasurer.*

MEETING OF NEW YORK SECTION OF THE ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

The New York Section of the Association of Teachers of Mathematics in the Middle States and Maryland gave a dinner at the Hotel St. Denis, New York City, on the evening of January 6, 1911.

The guests of the evening were the American Commissioners of the International Commission on the Teaching of Mathematics: Professor David Eugene Smith, Columbia University; Professor W. F. Osgood, Harvard University; Professor J. W. A. Young, Chicago University.

In order to make the evening as pleasant as possible socially, the Executive Committee arranged to seat teachers and their friends from one school at a table together, after having secured one teacher from the school to act as host. The success of this plan was shown by the fact that there were two tables of seventeen each, two of sixteen each, and others of eleven and smaller numbers, the total attendance amounting to one hundred and seventy-six.

The menu of the dinner was excellent, ranging from "Singular Points. Construct Points of Contact," through "Sections of Solids. Without reference to diameters or circumferences, find the cutting speed and feed," and "Polar Systems. Find the temperature," to "Series of Polyhedrons. Should this series be convergent, or do you prefer no limit?"

At intervals during the evening there was singing, with a fine leader and a fine pianist. The songs were the college songs of our guests, and parodies on some familiar airs, such as "Euclid had a little book" to the tune of "Mary had a little lamb."

Toward the end of the dinner, the chairman of the section, Mr. D. D. Feldman, in a few happy remarks turned the meeting over to Dr. Smith. He spoke of the work of the Commission, and then announced the other speakers. These speakers included the Commissioners and Professor C. B. Upton of Teachers' College, who attended the first meeting of delegates of the International Commission held in Brussels. Our sympathy for Dr. Young, who was called away early in the evening on account of the illness of Mrs. Young, was divided with our sympathy for ourselves that we did not hear from him.

At the short business meeting which took place at the close of the dinner, the following officers were elected: Chairman, Mr. Eugene R. Smith, Brooklyn Polytechnic Institute; secretary and treasurer, Miss Helen Clarke, Morris High School; member of the executive committee, Mr. D. D. Feldman, Erasmus Hall High School.

The Committee trusts that the inspiration of these reports will give added life to the work of the Section.

LAO G. SIMONS, *Secretary and Treasurer.*

CONFERENCE ON THE TEACHING OF NATURE-STUDY-AGRICULTURE.

The Second Annual Conference on the Teaching of Nature-Study-Agriculture in the rural elementary schools of Illinois was held at the College of Agriculture, Urbana, Ill., Wednesday to Saturday, January 18-21. Wednesday and Thursday were devoted to visitation of classes in the Agricultural Short Course. On Wednesday evening an illustrated lecture, "School and Home in Nature Study and Health," was given by Mr. J. K. Stableton, superintendent of schools, of Bloomington, Ill.

The first special session of the conference occurred Thursday afternoon, at which time "Agriculture in the One-room School" was discussed by County Superintendent A. M. Shelton of McHenry County. He urged the preparation of simple bulletins for the uses of the schools. Friday morning was devoted to report of the committee appointed by the first conference (held last March) on a Course of Study in Nature-Study-Agriculture. This report was discussed by Professor Fred L. Charles, Miss Alice J. Patterson, County Superintendent McIntosh, and Professor W. C. Bagley. The course provides a progressive study of environmental materials through the eight years of the rural elementary schools. It is not restricted to agriculture, the topics being chosen from the whole range of common affairs of country life. Much interest was manifested, particularly by the large number of county superintendents of schools who were in attendance upon the conference. Several of those present stated that they would try the course out this spring and next year. The plan is on the basis of this experience to revise and strengthen the course with a view to incorporating it in the forthcoming edition of the Illinois State Course of Study for Rural Schools. It was urged here, as on the previous day, that the success of the course is dependent primarily upon the kind of

literature which can be provided for teacher and pupils. There was general agreement that the university should publish simple bulletins dealing with each type study in the course and prepared specifically for school use. It was explained that such literature would have been undertaken before this time if funds for publication had been available. It is hoped that much may be done in this direction in the near future.

Friday afternoon the subject of "Boys' and Girls' Clubs" was discussed by County Superintendent E. C. Pruitt of Springfield, Ill., and Professor George Roberts of the University of Kentucky. It was decided to call a meeting to form a tentative plan for a state association of boys' clubs. This meeting was called at the close of the afternoon program, and was attended by representatives from about thirty-five counties of the state. A committee of seven representing each portion of the state was appointed to draw up a plan of organization. The formal lecture of the afternoon was delivered by Dean Davenport of the College of Agriculture, who spoke most convincingly on "Practical Education for Country Boys and Girls." At the close of his address Dean Davenport made an appeal for more generous support of the College of Agriculture, which he stated must receive much greater appropriations at once or must materially reduce its operations and limit the number of students. Saturday morning Assistant State Superintendent U. J. Hoffman addressed the conference on "The Illinois Standard One-room School." The signs were never more hopeful, he said, than now for better country schools. Mr. Hoffman was followed by President John W. Cook of the Northern Illinois State Normal School, who held the closest attention of the large audience to his theme of "Country Boys and Girls."

The conference closed Saturday noon, after passing the following resolutions: (1) That the conference be perpetuated and a meeting held annually in connection with the Agricultural Short Course; (2) that the university be requested to publish as soon as possible special bulletins supplementary to the course of study in nature-study-agriculture; and (3) that all possible aid and encouragement be given to the movement to organize a state association of boys' and girls' clubs.

A GROWING LABORATORY APPARATUS CONCERN.

The year 1910 has been a record breaker for the Chicago Apparatus Company of Chicago, Illinois. Their total sales for this year increased 67.39% over the previous year. The success of this rapidly growing concern is due to the liberal business policy which they employ, their aim being to supply only the best grade of apparatus and supplies at reasonable prices. Another factor which is largely responsible for the constantly increasing popularity of their goods is the fact that their apparatus and their line of supplies fully meet the requirements of the science courses now in use. Their ability to make low prices is due to the fact that they are manufacturers, not jobbers, selling direct to educational institutions at prices based on the actual cost of production. They have placed on the market many new and improved forms of apparatus that have become very popular and which are rapidly finding their way into every well-equipped laboratory. Their products are now used in over 4,000 Universities, Colleges, High Schools, Academies, etc., in the United States and Canada. Leading science instructors have indorsed their apparatus as it possesses many special features and advantages. It will be to the advantage of all buyers and users of scientific apparatus and supplies to consult their general illustrated catalogue.

BIOLOGY TEACHING.

A meeting of men interested in the advancement of biological teaching in secondary schools was held at the Harvard Union, Cambridge, on Saturday, February 4. Those present were Professor G. H. Parker, *Harvard University;* Principal Irving O. Palmer, *Newton Technical High School;* Dr. H. R. Linville, *Jamaica* (N. Y.) *High School;* R. H. Howe, Jr., *Middlesex School;* Samuel F. Tower, *Boston English High School;* S. Warren Sturgis, *Groton School;* Head Master Frank E. Lane, and W. L. W. Field, *Milton Academy.* The relation of school biology to civics, the sequence of laboratory experiments, outdoor work with classes, and college requirements were the topics informally discussed. The undersigned was authorized to communicate with other teachers with a view to establishing a series of conferences, perhaps to be held alternately in Boston and New York. Correspondence is accordingly invited from interested readers of this notice.

Milton Academy, Milton, Mass. W. L. W. FIELD.

BOOKS RECEIVED.

Plane and Spherical Trigonometry. By Arthur Graham Hall, University of Michigan, and Fred Goodrich Frink, University of Oregon. X+176 pages. 16x24 cm. Henry Holt & Co., New York.

A Laboratory Manual of Physical Geography. By R. S. Tarr and O. D. Von Engeln, Cornell University. XVII+362+16 pages. 21x25 cm. $1.25, net. The Macmillan Company, New York.

Elements of Business Arithmetic. By Anson H. Bigelow, Superintendent of Schools, Lead, S. D., and W. A. Arnold, Normal School, Woodbine, Ia. XI+258 pages. 13.5x19 cm. 70 cents, net. The Macmillan Company, New York.

Training of Teachers for Secondary Schools in Germany and the United States. By John Franklin Brown. X+335 pages. 14x19 cm. $1.25, net. The Macmillan Company, New York.

Teaching of Agriculture in the High School. By Garland Armor Bricker, Ohio State University. XVI+202 pages. 14x19 cm. $1.00, net. The Macmillan Company, New York.

Journal of the Proceedings of the Forty-eighth Meeting of the National Education Association. 1,124 pages. 17x25 cm. University of Chicago Press.

Year Book and List of Members of the National Education Association. 303 pages. 17x25 cm. University of Chicago Press.

English Grammar by Parallelism and Comparison. By G. W. Henderson. 165 pages. 14x20 cm. H. H. Henderson, Publisher, Columbus, O.

BOOK REVIEWS.

Missouri Botanical Garden. Twenty-first Annual Report. Pp. 195. St. Louis. 1910. Published by the Directors.

The present volume contains the reports for the year 1909 of the president of the Board of Trustees and of director of the garden. It is encouraging to all who are interested in the progress of American botany to note the growth of this important botanical institution.

From the report of the director, Dr. Trelease, we note that the collections of the garden contained 11,764 species of living plants, 655,825 specimens in the herbarium, and 61,654 books and pamphlets. The periodicals received number 1,464. This great mass of material is indexed upon nearly three-fourths of a million index cards.

The new building for herbarium, library, and laboratory purposes has been occupied and the Shaw School of Botany has been considerably enlarged in both teaching force and pupils. A very considerable amount of instruction and research has been carried on at the garden each year, but financial limitations have not allowed this work to be expanded to dimensions that were at all commensurate with the opportunities offered by the combination of library, herbarium, living collections, and greenhouses. Present plans look toward a much larger utilization of these facilities. We shall hope to see the "Shaw Gardens" take a leading place among the institutions for botanical research in America.

Many visiting botanists have taken advantage of the generosity of the garden in placing its facilities at their disposal; others have been assisted by loans of books or other materials.

Eight papers of considerable technical interest are appended to the report. They cover a variety of topics but a critical review of them would be more appropriate to the technical journals.

W. L. EIKENBERRY.

Elements of Plane Trigonometry, by Robert E. Moritz, Ph.D., Professor of Mathematics, University of Washington. Pp. xiv+361+91. 1911. Price, $2.00. John Wiley & Sons.

The author considers that trigonometry is preëminently college mathematics. From this point of view he has prepared a systematic exposition of the subject, in which a too ready knowledge of elementary mathematics and no knowledge of the topics usually treated in college algebra is presupposed.

Many of the more important formulas and relations have been derived by two methods, analytically and geometrically. Every example worked out in the book is checked, and the answers are given to a part of the exercises only, in order that the student may learn to check his results. The applied problems have been carefully selected from physics, engineering, navigation, astronomy, geography, and elementary geometry.

The accuracy of results as affected by the data and the use of tables is discussed at some length, and the student is warned against a show of accuracy in answers not warranted by the data. In general, the answers in the book are given to a number of significant figures consistent with the data. But in too many cases there is a failure to observe the principles of computation with approximate number, and computed parts of triangles are given a greater number of significant figures than the given parts have.

By making the angle the central idea of trigonometry, it has been possible to introduce and develop logically several concepts and processes generally reserved for advanced courses in mathematics. The chapter on trigonometric curves includes simple harmonic curves in which the angle is expressed as a function of the time, the composites of sinusoidal curves, Fourier's theorem, logarithmic and exponential curves, the compound interest law, the catenary, and the curve of damped vibrations. Complex quantities are discussed very clearly in the chapter on the representation of complex quantities. Tests for convergency and divergency of series are established, and there is an excellent treatment of the derivation and use of logarithmic and trigonometric series. In the chapter on hyperbolic functions the analogies between the circular and hyperbolic functions are developed both analytically and geometrically, and the area of a hyperbolic sector is determined.

The historical notes throughout the book give the student much interesting information. As a comprehensive and systematic exposition of the subject the present volume probably surpasses any trigonometry that has been published in this country. It should be in every high-school library, and every teacher of mathematics will find it of great value as a reference book. The publishers have done their part towards making a very attractive book, and it only remains for someone to give a satisfactory reason for the omission of the tables of proportional parts. H. E. C.

Elementary Solid Geometry, by John C. Stone, Head of the Department of Mathematics, State Normal School, Montclair, N. J., and James F. Millis, Head of the Department of Mathematics, Francis W. Parker School, Chicago. Pp. vi+159. Price, ——. 1911. Benj. H. Sanborn & Co.

In preparing this book the authors have followed the general plan of their Plane Geometry. The test of class-room use has shown that the latter book was well conceived and gives pupils not only a knowledge of geometrical relations, but also the ability to apply their knowledge to the problems of everyday life. Undoubtedly, the Solid Geometry will prove to be an equally satisfactory text-book.

The purpose and value of real applied problems is well stated by the authors. "Through the introduction of a large number of applied problems such as are actually encountered in practical life, the student is led to see the subject as a scientific instrument used in doing the world's work. Through the use of these real applied problems a strong appeal is made to the interest of the student, and a powerful and legitimate motive is furnished for studying the subject. All of these problems make genuine applications of the theorems of geometry. Hence, through their solutions the student's knowledge of the principles of geometry is led to function. We believe it the duty of the school to assist in this by teaching the student, before he leaves school, how to use this knowledge. Also, real applied problems have a value not possessed by the abstract or traditional artificial ones in furnishing an insight into things in the world about him which, except for the use of these problems, will always remain unknown or a mystery to the individual."

The applied problems and old-type geometrical exercises are well graded and put together in lists of ten to twenty at frequent intervals throughout the book. This brings the applications in close touch with the theorems involved.

The plan of leaving the whole or a part of the proof of a considerable number of theorems for the pupils to work out is to be commended. It prevents memorizing on the part of the pupil, and gives him a sense of the value of his work. An exercise is proved, and that is usually the end of it: but a theorem is proved for the purpose of further use.

The omission of theorems of little importance and the assumption of certain theorems whose proof is difficult gives ample time for valuable work in drawing, construction, and computation. Since the numbers in the applied problems are obtained from measurements, and are therefore approximate numbers, the pupils have an opportunity of learning those short methods of computation and common-sense checks which are of the highest importance in practical work. H. E. C.